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# ATTEMPT

To demonſtrate, That all the

*Phænomena in Nature*

May be explained by

Two ſimple active Principles,

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May be explained by

# Two ſimple active Principles,

ATTRACTION *and* REPULSION:

WHEREIN

The ATTRACTIONS of COHESION, GRAVITY, and MAGNETISM, are ſhewn to be one and the ſame; and the *Phænomena* of the latter are more particularly explained.

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By *GOWIN KNIGHT*, M.B. *F.R.S.*

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*Remember*, *Man*, "*The Univerſal Cauſe*
"*Acts not by partial, but by general Laws.*" POPE.

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# THE INTRODUCTION.

THE ſlow Progreſs that has been made in the Improvement of Natural Philoſophy in former Ages, is rather to be attributed to the wrong Methods they employed in making their Inquiries, than either to their Want of natural Abilities, or ſufficient Application. Some Centuries were ſpent by the Induſtrious Schoolmen in Searching for that Knowledge in their own Brains, which was only to be found by a diligent Inquiry into the Works of Nature, careful Obſervation, and accurate Experiments. *Des Cartes* was ſenſible of the Fallibility of human Reaſon, and imputing to that the Errours of preceeding Philoſophers, was reſolved to be upon his guard himſelf. Yet in ſpite of all his Precaution, the Strength of his Imagination hurried him into many Errours. Nevertheleſs, his Writings were ſo far of Service to the World, as their Ingenuity recommended them to the Peruſal of Men of Parts, and improved their Reliſh for Philoſophical Learning; whilſt their Errours taught others how little we ought to rely upon mere *Hypotheſis*, and put them upon a more diligent Application to thoſe rigid Teſts of Truth, Experience and Mathematicks. From this Source we may fairly deduce the many and ſurpriſing Diſcoveries of the laſt and preſent Age. Yet even thoſe ſeem capable of making but little Progreſs, unleſs rightly applied to the Inveſtigation of the general Laws of Nature; from which (if once known and explained) all the ſeveral Effects that depend on them may be readily deduced. A greater Progreſs has been made in Phyſicks by Sir *Iſaac Newton* alone, than by all the Philoſophers before or ſince him put together. Not that he had tried more Experiments than them all; but becauſe from thoſe, which he had tried, he was able to explain the Laws of Motion and Attraction, and the Properties of Light and

Colours, from whence an infinite Variety of other Truths were eaſily deduceable to his penetrating Genius.

When we conſider the vaſt Variety of Effects, that are explicable from Attraction alone; it will appear more than probable, that a few other Principles, as extenſive, and as clearly explained, may open a Door to the moſt ſecret Myſteries of Nature. In purſuing this Thought I was gradually led to examine whether Repulſion was not a Principle of this Kind; and whether that and Attraction might not alone be ſufficient to account for all the *Phænomena* with which we are acquainted.

There are few Perſons, even among thoſe that are well acquainted with Nature's Simplicity, to whom this Thought will not at the firſt View appear too bold, if not wild and extravagant.

But who can determine how much may be effected by two ſuch Principles, when directed by a Being of Infinite Wiſdom? Even human Invention affords us an Inſtance of a Thing, which (if it be of mere human Invention) is ſcarce leſs ſurpriſing, I mean the Uſe of Letters. The Art being common and familiar to us, we ſeldom reflect upon the wonderful Contrivance. But an entire Stranger to it would never comprehend how it was poſſible to expreſs all the various Sounds, not only in this, but every other Language, by twenty-four Characters, eſpecially if he was told that five of them alone gave the others all their Force. The Language of Nature, though more copious, is far more ſimple than ours; and a few Characters once decyphered will help us to diſcover the reſt. If Reaſon and Experience ſhall appear to countenance this Suppoſition (however extraordinary it ſhould ſeem at firſt) it may very well deſerve to be ſeriouſly examined. As far as I have hitherto gone, I have endeavour'd at the Simplicity and Clearneſs of a Mathematical Demonſtration: Firſt laying down ſuch Truths as are plain to common Senſe; and from them, by neceſſary Concluſions, deducing others leſs obvious.

PROPO-

## PROPOSITION I.

SINCE all natural Knowledge takes its Riſe from obſerving the various *Phænomena* of Nature, and ſearching out the Cauſes of them; the ſhorteſt Way to arrive at it, is to find out thoſe general Laws, by which a few ſimple Cauſes are enabled to produce a great Variety of Effects.

For if the infinite Variety of Effects required a diſtinct Cauſe to be aſſigned to each, it would be an endleſs Undertaking.

## PROP. II.

A Knowledge of the general Laws of Nature can no ways be acquired, but by taking a View of the ſeveral Works of the Creation, and obſerving what general Truths we can diſcover.

For general Concluſions can be inferred only from a View of Particulars.

## PROP. III.

The moſt general Truth that occurs to us, in contemplating the Works of the Creation, is, that there is a Being of infinite Wiſdom, and Goodneſs, and Power, the firſt Cauſe of all Things.

This is a Propoſition to which (one would imagine) no Man who had ever caſt an Eye on the Works of Nature, could deny his Aſſent. But if any ſuch there are, the beſt Advice I can give them, is, To look again.

## AXIOM I.

If we admit that *GOD*, the Supreme Being, is the firſt Cauſe of all things; all other Cauſes muſt be either immediately, or mediately derived from Him.

## DEFINITION I.

Immediate Cauſes are the Acts of *GOD* himſelf; depending only upon His Will for their Exiſtence and Continuance.

## PROP. IV.

No more Immediate Cauſes can exiſt in Nature, than are abſolutely neceſſary.

For *GOD* never Acts but for ſome wiſe Purpoſe. Whence it has been receiv'd as an Axiom in Phyſicks, that Nature does nothing in vain. And Sir *Iſaac Newton* has laid it down as a Rule, That no more Cauſes ought to be admitted, than are really found in Nature, and are neceſſary towards explaining the ſeveral *Phænomena:* And alſo, that Effects of the ſame kind proceed from the ſame Cauſe.

### DEF. II.

Mediate Cauſes are ſuch as ariſe from Immediate ones.

### PROP. V.

More Mediate Cauſes, than one, muſt depend upon every Immediate Cauſe.

For it would be inconſiſtent with Divine Wiſdom to create one Cauſe merely for the Sake of producing a ſecond; which doubtleſs he might as well have produced immediately.

### COROLLARY.

Every Mediate Cauſe is leſs general, than the Immediate one from which it proceeds.

### PROP. VI.

Every Cauſe is the Effect of ſome prior Cauſe, and that of ſome other, and ſo on, in a continued Chain; 'till we arrive at *GOD*, the Firſt Cauſe.

For there is no ſelf-exiſtent Cauſe, but *GOD*.

### PROP. VII.

All thoſe Properties, that belong to all Matter in general, can only be aſcribed to the immediate Will of *GOD*.

For there is no other Cauſe to be found, more general, than themſelves, to which they can be aſcribed. *Coroll. Prop* 5. Such are uſually called the eſſential Properties of Matter.

### COROLL. I.

Wherefore the Exiſtence, Extenſion, Impenetrability, Mobility, and *Vis Inertiæ* of Matter, are apparently the immediate Effects of *GOD*'s Will.

### COROLL. II.

All immediate Cauſes, being the Effects of *GOD*'s Will, muſt neceſſarily be conſtant, immutable, and irreſiſtable by any finite Force. From hence appears the Truth of Sir *Iſaac Newton*'s third Rule, *viz.* "Thoſe Qualities of Bodies, which

" can neither be increaſed, nor diminiſhed, and are common " to all Bodies, that come under our Examination, ought to " be admitted as general Qualities of all Bodies.

### PROP. VIII.

Beſides the general Properties of Matter abovemention'd, there is in Nature ſome Active Principle or Principles capable of producing and continuing Motion in the Univerſe.

For thoſe Properties being perfectly inactive, are of themſelves incapable of producing any one Effect. And Motion is itſelf no eſſential Property of Matter: becauſe it may be either produced, increaſed, diminiſhed, or deſtroyed in any Body whatſoever.

### DEF. III.

Attraction is that Cauſe which makes Bodies tend mutually to approach each other with different Forces at different Diſtances.

### DEF. IV.

Gravity is that Species of Attraction which makes the Moon and all Sublunary Bodies tend towards the Centre of the Earth: and all the Heavenly Bodies, within the Solar Syſtem, towards the Sun.

### DEF. V.

Coheſion is that Species of Attraction which makes the Particles of Matter, when almoſt in Point of Contact, tend to unite and adhere together.

### PROP. IX.

Attraction does really exiſt, and is an univerſal Cauſe that acts upon all the Bodies in Nature, of which we have any Knowledge; and this it does in two Shapes, that of Gravity, and that of Coheſion.

For Experience ſhews us, that all Bodies do gravitate; and alſo that their conſtituent Parts adhere together with a greater or leſs Degree of Coheſion.

### PROP. X.

The Attraction, both of Gravity and Coheſion, can only be aſcribed to the immediate Will of *GOD*.

For there is no other Cauſe more general than themſelves. *Corol. Prop.* 5, *and Prop.* 7.

## PROP. XI.

If two Particles indefinitely ſmall, at a given Diſtance, attract each other with any given Force, how ſmall ſoever; and that Force increaſes, as the Diſtances or the Squares of the Diſtances decreaſe; or in an higher Ratio: ſuch Particles, in Point of Contact, will adhere with indefinite Force.

*Firſt*, Suppoſe the Force increaſes ſimply as the Diſtances of the Surfaces decreaſe; then at half the given Diſtance they will attract with double the Force, at half that Diſtance with four times the Force, at the next half with eight times, and ſo on; for any given Diſtance may be divided *ad infinitum*: ſo that in Point of Contact their attracting Force will have undergone an infinite Increaſe, and conſequently be infinite. Now this will be the Increaſe, if the Force of Attraction is computed from the Surfaces; but ſince the Force is always to be computed from the Centers of the attracting Bodies, which in this Caſe are at an indefinitely ſmall Diſtance from each other, the Force in Point of Contact, though not infinite, will be greater than any that can be aſſigned. And if this holds good in the ſimple reciprocal Ratio of the Diſtances, it is eaſy to perceive that it will much more do ſo, if the Force be ſuppoſed to increaſe in an higher Ratio.

## COROLLARY.

The larger any two Bodies are, the leſs will be their attracting Force, in Proportion to their Quantities of Matter, in Point of Contact; their Centers being proportionably at a greater Diſtance from each other.

## PROP. XII.

There muſt be ſome other active Principle in Nature beſides that of Attraction.

For Attraction and the general Properties of Matter will ſerve to explain very few *Phænomena*, when conſidered alone.

Amongſt the Heavenly Bodies, indeed, their Rotations and Revolutions might go on to Eternity very well, while their gravitating Force was counterballanced by their *Vis Centrifuga*. But on each particular Globe a perpetual Darkneſs would every where prevail, an inſuperable Bond of Attraction would deſtroy both Fluidity and Motion, and all Nature wou'd be at a ſtand.

Some faint Idea may be form'd of ſuch a State, from the Relation of ſuch Travellers as have wintered near the *North-Pole:* Where, during the Abſence of the Sun, the Principle of Attraction becomes ſo predominant, that nothing but a large Fire, and a cloſe Room, can preſerve either Animals, or Plants, or Fluids, from growing hard as a Rock.

## DEF. VI.

Repulſion is that Cauſe which makes Bodies mutually endeavour to recede from each other, with different Forces at different Diſtances.

## PROP. XIII.

The Effects of Repulſion are directly contrary to thoſe of Attraction. *Def.* 3 *and* 6.

## PROP. XIV.

There is really exiſting in Nature ſuch a Cauſe as Repulſion.

In order to reconcile what is demonſtrated in *Prop.* 11 *and* 12. with the real *Phænomena* of Nature, we muſt neceſſarily admit of ſome contrary Cauſe, that may be able to counter-act and limit the Force of Attraction; which otherwiſe would every where too much prevail. That Repulſion is ſuch a Cauſe is evident from the laſt *Prop.* And we have likewiſe ſufficient Evidence of its Exiſtence, from Facts and Experience. For all Bodies are electrical, or capable of being made ſo: and electrical Bodies both attract and repel. *Secondly*, Both Attraction and Repulſion are very conſpicuous in all magnetical Bodies. *Thirdly*, Sir *Iſaac Newton* has ſhewn from Experiment, that the Surfaces of two convex Glaſſes repel each other.

*Fourthly*, The ſame great Philoſopher has explain'd the Elaſticity of the Air by ſuppoſing its Particles mutually to repel. *Fifthly*, The Particles of Light are, in Part at leaſt, repelled from the Surface of all Bodies. *Laſtly*, It ſeems highly probable that the Particles of Light mutually repel each other. The Air is always rarified by Heat; and that in a greater Proportion, as the Heat is more intenſe. What then muſt that Rarefaction be in the Focus of *Villette*'s *Speculum*? Perhaps a more perfect Vacuum would not be produced by the beſt Air-Pumps. But ſuppoſe half the Air ſtill remaining, its expanſive Force will be equal to a Column of Mercury of fifteen Inches in height; whoſe Baſis will be equal to an imaginary Surface ſurrounding the whole focal Space. But the Atmoſphere will preſs with a Force equal to a Column of the ſame Baſe, and thirty Inches in height. What is it that ſupports this extraordinary Weight? A *Carteſian* will tell us, perhaps, that there is no Vacuum at all: But that the Air is drove out of its Place by the Subtile Matter; which being moved with great Rapidity by the Matter of the firſt Element, *i. e.* Light, and whirl'd round in a Vortex; by its Centrifugal Force is determined every way to fly off; and ſo counter-acts the Preſſure of the Air. But how can Light, which moves, in this caſe, all of it in one Direction, communicate a Motion to the Subtile Matter ſo, that it ſhall act in all Directions? Another Difficulty ariſes from a Defect in the Momentum of Light: which being ſuppoſed the *Primum Mobile*, ought to act with a Force equal to ſeveral Pounds of Mercury. Now as all theſe Difficulties vaniſh; if we only admit a Repulſion betwixt the Particles of Light themſelves, and betwixt them and Air, we can have no Reaſon to doubt of the Fact, eſpecially ſince it is plain, from the Arguments above, that there is ſuch a Cauſe as Repulſion in Nature. "For no Cauſe ought to be ad-" mitted, but what is really found in Nature, and no more " than are neceſſary towards explaining the ſeveral *Phænomena*. *Prop*. 4.

## PROP. XV.

Repulſion is a general Cauſe, the immediate Effect of *GOD*'s Will.

It has, I think, been ſufficiently proved in the laſt Propoſition, that Repulſion is either found, or capable of being produced in all the Bodies that come under our Examination. And it ſeems alſo probable, that the Particles of Light mutually repel each other; and if ſo, it is not only univerſal in all Parts of the Earth, but throughout the immenſe Space of the whole viſible World: Since there is not a Point of that Space, in which the Light of ſome of the HeavenlyBodies is not perceiveable to the naked Eye. Wherefore Repulſion is the moſt general ſecondary Cauſe yet diſcover'd in Nature; excepting Attraction, and the other eſſential Properties of Matter, which can produce no Effect by themſelves; and the Effects of Attraction are directly oppoſite to thoſe of Repulſion. It is therefore the immediate Effect of *GOD*'s Will. *Corol. Prop.* 5.

## PROP. XVI.

If two Particles indefinitely ſmall, at a given Diſtance repel each other with any given Force, how ſmall ſoever; and that Force increaſes as the Diſtances decreaſe, or as the Squares of the Diſtances, or in an higher Ratio: Such Particles will in Point of Contact repel with an indefinite Force.

The Demonſtration of this *Prop.* is exactly the ſame with that of *Prop.* 11. *mutatis mutandis:* It is therefore needleſs to repeat it. But it may not be amiſs to obſerve, that the Truth of this is leſs repugnant to the common Appearances of Nature The Increaſe of repulſive Force in the Particles of the Air, by their mutual Approach in a condenſing Engine, correſponds very well, as far as we can or dare proſecute the Experiment. In the Exploſion of Gun-Powder, the Air, or ſome other expanſive Vapour, newly generated from the Nitre and other Ingredients, inſtantly expands itſelf with a Force that ſeems irreſiſtable, and if not infinite, may very well paſs for indefinite, till we can aſſign a Force that it is not able to overcome; and yet there are ſome Chemical Preparations, that appear much more violent in their Effects, than Gun-Powder itſelf.

## PROP. XVII.

Repulſion alone, without Attraction, would not be ſufficient to explain the *Phænomena* of Nature.

For a mutual Repulſion among all the Parts of Matter would reduce it to Atoms, and diſperſe it equably through every Part of Space. If it was peculiar to ſome Part of Matter, that Part would undergo the ſame Fate, and the reſt would remain unactive and indifferent.

## PROP. XVIII.

Both Repulſion and Attraction are conſtant, immutable, and irreſiſtable by any finite Force. *Corol.*2. *Prop.*7. *Prop.*10, & 15. And that their Force is irreſiſtable in Point of Contact (in which Caſe only they act with their whole Force) is already demonſtrated. *Prop.*11, 16.

## PROP. XIX.

Attraction and Repulſion cannot both, at the ſame Time, belong to the ſame individual Subſtance, being Contraries. *Prop.*13.

The ſame Body cannot have a Tendency to move two Ways at once.

*Note*, It muſt not be inferred from the laſt Propoſition, that Attraction and Repulſion are not Immediate Cauſes: For tho' they cannot both be the Properties of all Matter, it will be ſufficient if they be more general than any other Cauſe; excepting thoſe eſſential Properties of Matter, which are altogether unactive alone.

## COROL.

Therefore we muſt conclude, that there are in Nature two Kinds of Matter, one attracting, the other repelling.

## PROP. XX.

Thoſe Particles of Matter, that mutually repel each other, ſeem in reſpect of other Matter alſo ſubject to the general Law of Attraction.

This Propoſition includes in it no Contradiction: And Experience tells us, that Light, falling obliquely towards the Surface of tranſparent Bodies, is either repelled before it arrives at it, or determined towards the Perpendicular, and then tranſmitted. Moreover, Air always adheres to the Surfaces of Bodies; and it is intimately united throughout the whole Subſtance of ſome in great Quantities. See *Hales*'s *Analyſis of the Air*.

## PROP. XXI.

If the eſſential Properties of Matter, in Conjunction with the two active Principles of Attraction and Repulſion, will alone explain all the *Phænomena* of Nature; no other Immediate Cauſe ought to be admitted.

For theſe do really exiſt. *Prop.* 9, 14. And no more can exiſt than are abſolutely neceſſary. *Prop.* 4.

## COROL.

Wherefore it would be unphiloſophical to ſeek after any other Cauſe, till we are certain that theſe few are not ſufficient.

## PROP. XXII.

The primary Particles of Matter muſt neceſſarily have both Bulk and Figure of ſome Kind or other.

This is a neceſſary Conſequence of Extenſion, one of the eſſential Properties of Matter.

## PROP. XXIII.

All the Operations in Nature are performed with the greateſt Simplicity that is poſſible.

For Nature does nothing in vain.

## COROL.

As our Intention is to reduce the ſeveral Kinds of Attraction and Repulſion to two only, this Propoſition will aſſiſt us in determining the Ratio in which their Forces act at different Diſtances. I think the ſimpleſt that we find in Nature, is the reciprocal Ratio of the Diſtances; and if ſo, this Propoſition determines us to pitch upon that, if we can find any Way of reconciling all the others to it. The Magnetical Attraction is in ſome Caſes found in this Ratio; and the Repulſion betwixt the Particles of the Air is always ſo, as far as we can judge: So that we have evidently ſome Foundation

dation in Nature for the Suppoſition; ſince this Ratio does really exiſt in both Principles.

## PROP. XXIV.

All the primary Particles of Matter are originally of the ſame Size, and all round.

This is more ſimple, than if we were to ſuppoſe them of different Sizes and Shapes, or of any other Shape beſide this. So that unleſs different Sizes and other Shapes were neceſſary, which as yet we have no Reaſon to ſuppoſe, the Truth of this Propoſition is an evident Conſequence of the laſt.

## COROL.

If the primary Particles of Matter are all of the ſame Size, they may be conſidered as indefinitely ſmall, till we ſee ſome Reaſon to infer the contrary from ſome of the *Phænomena* of Nature. Experience tells us, that the primary Particles of Matter muſt be extremely minute; and Reaſon demonſtrates, that whatever is extended is likewiſe diviſible *ad infinitum*. So that there is no Degree of Minuteneſs, that may not reaſonably be aſcribed to them.

## PROP. XXV.

Matter was not created all in one Maſs, but diſpoſed throughout the whole Space of the Univerſe in ſuch a Manner, that when the Principle of Attraction was impreſſed upon it, it might run together into ſuch Forms, and acquire ſuch Motions, as the All-wiſe *CREATOR* foreſaw would be neceſſary in producing the Syſtem of the World, and were poſſible to be produced from ſuch a Diſpoſition.

*GOD* Almighty could, doubtleſs, with the ſame Facility create Matter in any Part of Space, by one ſingle Act of his Will. It is therefore abſurd to ſuppoſe, that he created it all in one Maſs, and then exerted a ſecond Act, to diſtribute it into different Maſſes, and different Parts of Space. Infinite Wiſdom could certainly diſcern the Effects that Attraction would produce in the Whole, and in every Particle of Matter; and without Doubt diſpoſed it in that Manner, which would be moſt conducive towards effecting the Formation of the Univerſe.

## PROP. XXVI.

Matter being thus conſtituted at the firſt Creation of it, and then a Principle of Attraction impreſſed upon it; the Conſequence muſt be, that thoſe primary Particles, according to their Diſpoſition, would mutually attract each other with different Forces, would immediately run together, and adhere in Point of Contact with indefinite Force. And according to the Number of Particles at that Time in the Neighbourhood of each other, there would be formed Corpuſcles of different Bulks. Thoſe Corpuſcles, according to their Diſtances from each other, would run together in like Manner, and form larger; and ſo on.

*Note* 1. It might be more methodical to proſecute here the firſt Formation of all the Heavenly Bodies, and explain the Origin of their Forms, their Magnitudes, Situations, and Motions; but as all that can be done in this reſpect would be to prove, that they might be the Effects of an artful Diſtribution of Matter, at the firſt Production of it, and of the general Principle of Attraction, governed by the Laws of Motion; it could not be neceſſarily inferred from thence, that thoſe Effects were actually produced in that Manner: I ſhall therefore poſtpone this Part of my Undertaking, till I have conſidered the more minute Parts of Nature.

*Note* 2. It is eaſy to perceive from the laſt Propoſition, that although the primary Particles of Matter were originally formed all of the ſame Magnitude, and indefinitely ſmall; yet by impreſſing on them a Principle of Attraction, they might be made to form themſelves into Corpuſcles of different Orders of Magnitude: But if any one thinks it more reaſonable to ſuppoſe them created of different Sizes at firſt, I have no Objection at preſent, except that it does not appear to me ſo ſimple, as if we ſuppoſe them created all alike.

## PROP. XXVII.

If a Number of Particles, of equal Magnitudes, and perfectly round, mutually attract each other with any Degree of Force at any given Diſtance, how ſmall ſoever, upon their mutual Conflux they will form themſelves into a Figure as nearly ſpherical as poſſible.

For Bodies that mutually attract each other will endeavour to approach as near as poſſible to their common Center of Gravity; conſequently they muſt endeavour to put on a ſpherical Figure as near as poſſible, there being no Figure that has all its Parts ſo near one common Center as a Sphere. And tho' at their firſt Conflux they ſhould have any other Shape, and adhere in Point of Contact with indefinite Force, yet they would immediately aſſume a ſpherical one; for being perfectly round and equal, they might either roll or ſlide one amongſt another, without any Hindrance from their Force of Coheſion.

## PROP. XXVIII.

Thoſe primary Particles of Matter, which mutually repel each other, would, if left to themſelves, diſperſe equably throughout the whole Infinity of Space.

For if there were fewer of them in one Part of Space than another, their expanſive Force would neceſſarily determine them to that Quarter, where there was leaſt repellent Force to reſiſt them; ſo that they would never be at reſt, till all were *in equilibrio:* And altho' a Diſtance could be aſſigned, at which they might ceaſe to repel, yet the Motion already acquired would ſtill continue *ad infinitum*.

## PROP. XXIX.

Either the World is infinite, or there is ſome Cauſe that prevents the Progreſs of Light beyond the Limits of the Univerſe.

For as Light diſperſes itſelf on all Sides from all the Heavenly Bodies, it will be continually flowing into the empty Space, and there continue its Motion *ad infinitum*; much more if its Particles mutually repel each other. *Prop*. 28.

## PROP. XXX.

The more grand our Conceptions are of the Works of the Creation, the more likely they are to be juſt.

For if we reflect with ourſelves who is the Author of them, we may clearly diſcern, that our finite Comprehenſions will always fall ſhort of the Truth.

## COROL. I.

Wherefore if the Supreme Being might with equal Facility create the World infinite as finite, and no Argument can be brought from Reaſon or Experience, that He has not done it; we ought to determine our Aſſent that Way which appears moſt ſuitable to the Nature of the firſt Cauſe.

## COROL. II.

Admitting the World to be infinite, we have no need of a Cauſe to limit the Expanſion of repelling Matter, or to prevent the univerſal Conflux of the attracting. The firſt will diſperſe itſelf as equally as poſſible through every Part of Space: The latter may be diſpoſed in ſuch a Manner, that each Syſtem of the Heavenly Bodies may be *in equilibrio* with thoſe that ſurround it.

## PROP. XXXI.

If a cubical Inch of Matter ſhould be divided into Parts indefinitely ſmall, and thoſe Parts were all placed at any given Diſtance from each other, how ſmall ſoever, they would be diffuſed through a Space that would be greater than any we can aſſign. This is an evident Conſequence of the infinite Diviſibility of Matter.

## COROL. I.

If the whole Space of the ſolar Syſtem was ſo full of repellent Particles, that in the Compaſs of every Cubic Inch there ſhould be an indefinite Number, yet the Whole of them might not weigh one Grain.

## COROL. II.

The whole Infinity of Space may be ſo full of repellent Particles, that no Part of it can be aſſigned ſo ſmall, as not to contain many Thouſands of them, and yet their Reſiſtance to the Motions of the Heavenly Bodies may be indefinitely little.

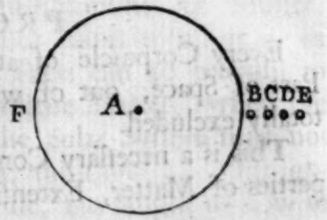
*Note* 1. When I ſpeak of Space being full of repellent Particles, I ſuppoſe a Vacuum every where interſperſed.

*Note* 2. This Reaſoning may probably appear extravagant to thoſe who have not ſufficiently conſidered the inexpreſſible Minuteneſs of ſome of the Works of Nature. Yet it is not only evident from Mathematical Demonſtration, that it may be true; but undoubted Facts and Experience convince us, that it is ſo. The Light of the Heavenly Bodies is at all Times viſible to the naked Eye, in every Part of the Univerſe, unleſs where ſome opake Body is interpoſed; and is every where ſo denſe, that the Number of Particles, which each Moment ſtrike upon the *Retina*, is at leaſt as great as the Number of the viſible Parts of all the Objects that can poſſibly be taken in at one View. If we look through the ſmalleſt Pin-hole, we may diſtinctly ſee all the Objects that are before us in a Room, and conſequently there muſt paſs through the Pin-hole, at the ſame Time, as many Rays of Light as there are viſible Parts in thoſe Objects; and that without Confuſion, or any ways interfering with each other. Nevertheleſs, as denſe as the Particles of Light appear to be in every Part of Space, ſuch is their Minuteneſs, and ſo ſmall their Quantity of Matter, that it gives no ſenſible Reſiſtance to the Motion of the Heavenly Bodies.

## PROP. XXXII.

If the whole Infinity of Space was filled with a Fluid, whoſe Particles were indefinitely ſmall, and mutually repelled each other in the reciprocal Ratio of their Diſtances, and this Fluid ſhould by any Cauſe whatſoever be either totally, or in Part excluded from any Part of Space, the Denſity of the Fluid immediately ſurrounding the ſaid Part of Space, would be increaſed in Proportion to the Number of Particles excluded.

Let the Sphere A repreſent a Part of Space ſurrounded with ſuch an elaſtick Fluid, but itſelf quite void of repellent Particles; and let B C D E repreſent a Series of ſuch Particles continued *ad infinitum.*



The Particle at B being ſurrounded with repellent Particles on one Side, but having a Space void of them on the other, will be determined towards the Center A, and preſſed upon the reſiſting Surface of the Sphere. *Prop.* 28. For the ſame Reaſon the Particle C will be determined towards the ſame Center, and preſs upon B till it has approached ſo near, that the repulſive Force of B, added to the repulſive Force of all the diſtant Particles beyond the empty Space about F, ſhall be equal to the repulſive Force of the infinite Series of Particles D E, *&c.* For the ſame Reaſon the Particle D will preſs upon C, and E upon D.

In like Manner, if the Space A contained fewer repellent Particles than the circumambient Space, the Particles B C D E, *&c.* will be determined towards A, with a Force proportionable to the Want of Reſiſtance on that Side, *i. e.* in Proportion to the Want of repellent Particles.

### COROL.

The larger the Space is, that is devoid of repellent Particles, the greater will be the Condenſation of the like Particles round it.

### PROP. XXXIII.

The Forces with which theſe Particles will be determined towards the Center of this empty Space, will be in the reciprocal Ratio of their Diſtances from that Center.

For two or more Particles, at different Diſtances from this Center, will be determined towards it with Forces exactly equal to thoſe with which they would be repelled, if the Space was filled with its due Share of repellent Particles; which Repulſion is ſuppoſed to be in the reciprocal Ratio of the Diſtances.

## PROP. XXXIV.

Every Corpuſcle of attracting Matter muſt occupy ſome Part of Space, out of which the repellent Matter will be totally excluded.

This is a neceſſary Conſequence of the two eſſential Properties of Matter, Extenſion and Impenetrability.

### COROL. I.

Wherefore the repellent Particles of our elaſtick Fluid will be condenſed round every Corpuſcle of attracting Matter, more or leſs, in Proportion to the Size of ſuch Corpuſcles. *Prop.* 32. and the *Corol.* And the Forces with which theſe Particles will be determined towards the Center of each Corpuſcle, will be in the reciprocal Ratio of their Diſtances from that Center. *Prop.* 33.

### COROL. II.

This Determination of the repellent Particles towards the Center of a Corpuſcle of attracting Matter, will be juſt the ſame in Effect, as if they were attracted towards that Center with a Force increaſing in the reciprocal Ratio of their Diſtances from it.

*Note*, On Account of this Reſemblance of an Attraction betwixt the attracting and repelling Matter, it is not eaſy to demonſtrate from Facts, that there is any real Attraction betwixt them; for thoſe ſeeming Appearances of Attraction, mentioned in *Prop.* 20. and others of the like Nature, may poſſibly be accounted for, from what is demonſtrated in the laſt Propoſition and the laſt Corollaries. However, till Reaſon or Experience ſhall appear to evince the contrary, I think I have a Right to aſſume that Side of the Queſtion, which ſhall be moſt likely to ſerve my Purpoſe; eſpecially as the Queſtion relates not to the introducing any new Property of Matter, but regards only the ſettling the due Extent of thoſe already demonſtrated. The great Founder of our modern Philoſophy has made the Attraction of Gravity univerſal to all Matter in general; whether the ſeveral Parts are in a State of Attraction or Repulſion in reſpect of each other, they ſtill gravitate in Proportion to their Quantities of Matter. The Truth of this is evident from Experience, as far as Experience can reach. But what Facts can be brought to prove the Gravitation of our repellent Matter, when the Whole that is contained within the Solar Syſtem may not equal a Grain in Weight? *Prop.* 31. and *Corol.* 1. Our excellent Philoſopher, in his *third* Rule, has taught us how to reaſon in Caſes of this Nature: For by that Rule, ſince Gravity is common to all Bodies that come under our Examination, it ought to be admitted as a general Quality, extending alſo to thoſe Bodies which it is not in our Power to examine. Now if we admit that repellent Matter gravitates, we muſt grant that it is attracted by the attracting Matter.

## PROP. XXXV.

Admitting that the repellent Matter is ſubject to the general Law of Attraction, in Contact it will adhere with indefinite Force. *Prop.* 11.

*Note*, As theſe two Cauſes conſpire in producing one Effect, namely, a mutual Approach betwixt the attracting and repelling Matter (for Brevity's Sake) I ſhall include both under one Name, *viz.* the Attraction of repellent Matter; except where there is a Neceſſity to diſtinguiſh them.

## PROP. XXXVI.

Every Corpuſcle of attracting Matter will have round it, (either adhering to its Surface, or condenſed in Form of Atmoſphere) as many repellent Particles as will juſt ballance its attracting Force.

For the Surface will have as many adhering to it, as can come in Contact with it: But when that is ſo full, that their repulſive Force will permit no more to come in Contact, they can only be condenſed round in Form of Atmoſphere, which will grow leſs and leſs denſe all the Way from the Surface, till the Repulſion of all the Particles collected round the Corpuſcle is ſufficient to ballance the condenſing Force, *Prop.* 32 and 34. *Corol.* 1. and then the next Series of repellent Particles, being repelled with as much Force one Way as they will have to attract them in the contrary Direction, will remain quieſcent. For equal contrary Forces muſt mutually deſtroy each other.

### PROP. XXXVII.

The Quantity of repellent Matter which will be collected round Corpuſcles of different Sizes will be in Proportion to their Magnitudes.

Since the Corpuſcles of attracting Matter are all compounded of Particles of equal Sizes, and perfectly round, *Prop.* 24. they will be all of equal Denſities; conſequently the Quantities of Matter in Corpuſcles of different Sizes will be in Proportion to their Magnitudes. Their attracting Force being as their Quantities of Matter, that muſt alſo be in Proportion to their Magnitudes. But the Quantity of repellent Particles collected round each Corpuſcle will be in Proportion to its attracting Force. *Prop.* 36. Wherefore the Quantity will be in Proportion to their Magnitudes.

*Note*, Theſe two laſt Propoſitions are univerſally true, ſuppoſing the repellent Matter always quieſcent; otherwiſe not, as appears from the two next Propoſitions and their Corollaries.

### PROP. XXXVIII.

The Quantity of repellent Particles, that will come in Contact with the Surfaces of the attracting Corpuſcles, will be nearly proportionable to the Largeneſs of thoſe Surfaces.

If the Attraction of the repellent Particles was the only Cauſe that acted, in bringing them in Contact with the attracting Corpuſcles, the larger Corpuſcles would have them ranged cloſer upon their Surfaces, than thoſe that are leſs. But this Conſideration would only take Place, whilſt the repellent Matter was in a quieſcent State; that is, ſo far quieſcent, as only to be actuated by the Repulſion of its own Particles amongſt themſelves, and the Attraction of the attracting Matter. But if we ſhould conſider theſe Particles vibrating backwards and forwards with great Force and Rapidity, in various Directions, and continually ſtriking upon the Surfaces of the attracting Corpuſcles, a very different Effect will be produced. In this Caſe, the larger Corpuſcles, in Proportion to their greater Quantity of repellent Particles already ſurrounding them, will have a greater Force to repel back again the Particles that impinge againſt them. So that moſt of the impinging Particles will be reflected, before they can come in Contact with the Surface. On the other hand, the ſmaller Corpuſcles, having fewer repellent Particles as yet united to their Surfaces, if others impinge with Force againſt them, will not have that Power to repel them, and hinder their coming in Contact. But all that do come in Contact will adhere with indefinite Force, *Prop.*11. and never be again ſeparated. Thus the ſmaller Corpuſcles will ſoon have their Surfaces covered as thick with repellent Particles as the large. That this Motion of the repellent Matter is not merely hypothetical, but has a real Exiſtence in Nature, will be clearer, when we come to make a more particular Inquiry into the Cauſe of Light and Fire. It will be enough for the preſent to ſhew, that Light agrees perfectly well with the Deſcription given of our repellent Particles in Motion: *Firſt*, Light conſiſts of Particles indefinitely ſmall. *Secondly*, They move with incredible Velocity. *Thirdly*, They are found in every Part of Space: For Light is ſenſible to our Eyes in moſt Parts of Space, and always produceable; and where it appears quite dark to us, many other Animals can ſee very diſtinctly. *Fourthly*, Its Particles ſeem mutually to repel each other. *Prop.*14. *Fifthly*, It is repelled from the Surfaces of attracting Matter, and that before it touches thoſe Surfaces. Till theſe Surfaces are ſufficiently guarded with repellent Particles, ought not Light to force its Way till it comes in Contact? I think the Agreement is ſo apparent, that it deſerves not to be further inſiſted on.

## COROL.

Therefore in a decreaſing Series of attracting Corpuſcles, the Quantity of repellent Matter adhering to their Surfaces will decreaſe nearly in Proportion as their Surfaces decreaſe.

PROP.

## PROP. XXXIX.

The ſmaller a Corpuſcle of attracting Matter is, the larger will be the Quantity of repelling Matter united to its Surface, in Proportion to the Magnitude of the Corpuſcle.

For the Magnitudes of the Corpuſcles decreaſe as the Cubes of their Diameters, the Surfaces only as the Squares; wherefore the Surfaces, and conſequently the Quantities of repellent Matter united to them, *Prop*.38. do not decreaſe ſo faſt as the Magnitudes of the ſaid Corpuſcles.

### COROL. I.

But if the Quantity of repellent Matter united be proportionably greater as the Corpuſcles diminiſh, the Quantity condenſed round muſt be proportionably leſs; ſince both together are in Proportion to the Magnitudes of the Corpuſcles. *Prop*.37.

### COROL. II.

If we conceive the attractingCorpuſcles ſo ſmall, that their Surfaces will be able to contain as much repellent Matter as is ſufficient to ballance their attracting Force, ſuch Corpuſcles will have none at all condenſed round them in Form of Atmoſphere. *Prop*.36. And if we conceive them ſtill leſs, ſuch Corpuſcles will contain more repellent Particles upon their Surfaces, than merely what are neceſſary to ballance their attracting Force. *Prop*.38.

### COROL. III.

Thoſe Corpuſcles that have not Surface enough to hold all the repellent Matter neceſſary to ballance their attracting Force, will have the Overplus condenſed round in Form of Atmoſphere. And the larger they are, the greater will be the Extent of that Atmoſphere. *Corol.* 1.

## PROP. XL.

Thoſe Corpuſcles that have more repellent Matter united to their Surfaces, than what is neceſſary to ballance their Force of Attraction, will mutually repel each other, with a Force proportionable to the Exceſs of their repellent Matter.

For a Body that is impelled by two contrary unequal Forces, will move in the Direction of the ſtrongeſt with a Force equal to its Exceſs.

## PROP. XLI.

The ſmaller ſuch repellent Corpuſcles are, the greater will be their repulſive Force, in Proportion to the Quantities of Matter.

For the ſmaller the Corpuſcle, the larger the Quantity of repellent Matter in Proportion to the attracting. *Prop.* 39. And the Corpuſcles repel with a Force proportionable to the Exceſs of their repellent Matter. *Prop.* 40.

## PROP. XLII.

Neutral Corpuſcles (or ſuch as have as much repellent Matter united to their Surfaces as will juſt ballance their attracting Force) will neither attract nor repel each other, except when they approach very near.

At any conſiderable Diſtance, the two Forces being equal, and contrary, will mutually deſtroy each other; but when ſuch Corpuſcles approach very near, the repellent Particles being external to the attracting ones, their Diſtances will decreaſe much faſter, than the Diſtances of the attracting Matter, and conſequently their Forces will increaſe faſter likewiſe: Since they are ſuppoſed to increaſe in the reciprocal Ratio of their Diſtances, and ſince the repellent Particles ſurrounding the Corpuſcles would in Point of Contact repel with indefinite Force (*Prop.* 16.) it is evident they can never be brought to touch by any finite Force.

## COROL. I.

This Repulſion of the Surfaces, whilſt the neutral Corpuſcles are at any conſiderable Diſtance, will be indefinitely ſmall: For the abſolute Forces of the attracting and repellent Matter being equal, their Difference can only ariſe from the Difference of the Diſtances at which they act: Wherefore the Difference of the Forces will be in Proportion to the Difference of thoſe Diſtances. The Diſtances only differ, in as much as the repellent Matter is external to the attracting. So that the Difference of Diſtances will, at moſt, be only equal to twice the Diameter of a repellent Particle. Therefore at any conſiderable Diſtance of the Corpuſcles, this Difference muſt be indefinitely ſmall; and conſequently the Difference of the Forces muſt be ſo likewiſe.

## COROL. II.

Since, when neutral Corpuſcles are brought very near, the Diſtances of their Surfaces will decreaſe much faſter than the Diſtances of their Centers, this Repulſion of the Surfaces will increaſe much faſter than in the reciprocal Ratio of the Diſtances of their Centers.

## COROL. III.

The Repulſion of the Surfaces takes place alſo in the attracting and repelling Corpuſcles, if they are made to approach near enough, and for the very ſame Reaſons.

## PROP. XLIII.

Thoſe Corpuſcles which, on Account of their Size, have Part of their repellent Matter ſurrounding them in Form of Atmoſphere, whilſt at a certain Diſtance, will neither attract nor repel; yet if they are brought ſo near together, that their Atmoſpheres begin to coincide, they will then begin to attract.

It is eaſy to conceive, that upon the mutual Approach of two ſuch Corpuſcles, the repellent Particles that compoſe their Atmoſpheres will recede backwards behind each Corpuſcle: So that when the Corpuſcles come to a certain Diſtance from each other, there will not be ſo many repellent Particles betwixt them, as will be ſufficient to ballance their Force of Attraction; on which Account they will run together, and their Atmoſpheres will coincide, ſo as to make up but one Atmoſphere to the whole.

## PROP. XLIV.

The larger theſe attracting Corpuſcles are, the greater will be the Diſtance at which they will begin to attract, and the greater the Force with which they will run together; and *vice verſâ.*

Becauſe the larger they are, the greater will be the Extent of their Atmoſpheres. *Corol.* 3. *Prop.* 39. Wherefore their Atmoſpheres will begin to coincide at a greater Diſtance, and they will begin to attract at a greater Diſtance. Alſo their attracting Force being, all the Way as they approach nearer, increaſed, and being likewiſe greater in Proportion to the Quantity of attracting Matter, the largeſt Corpuſcles muſt run together with the greateſt Force.

## PROP. XLV.

Although the attracting Corpuſcles can no more come in actual Contact than the neutral ones, their Surfaces being ſurrounded with repellent Particles which adhere with indefinite Force (*Prop.* 35, and 42.) yet they will approach nearer and nearer in Proportion to their Size. Thoſe of them which are largeſt will approach neareſt.

The Force of Attraction will make them approach, till that Force is overcome by the Repulſion of their Surfaces. Wherefore the leſs that Force is, the ſooner it will be overcome: Conſequently the ſmalleſt Corpuſcles, having leaſt attracting Force, will be ſooneſt ſtopped in their Approach, and the largeſt will approach neareſt.

### COROL. I.

Since all the Corpuſcles of attracting Matter are ſurrounded with repellent Particles, there can never be any real Contact, either betwixt thoſe Corpuſcles, or Bodies compounded of them.

*Note*, Wherefore when we ſpeak of the Contact of Corpuſcles or Bodies, no more is meant than that they are brought as near as the Repulſion of their Surfaces will admit.

### COROL. II.

After the attracting Corpuſcles are brought ſo near by the Exceſs of their attracting Force, as to have that Force ballanced by the Repulſion of their Surfaces, it will hardly be in the Power of human Art to compreſs them ſtill nearer, in any Degree great enough to be ſenſible: For the repellent Particles on the Surfaces are already compreſſed with a Force equal to the Exceſs of Attraction. This Force muſt be exceeding ſtrong in ſuch a Number of Corpuſcles, as are neceſſary to compoſe a Body of ſufficient Bulk to be examined by a mechanical Compreſſion. So extremely minute are even the largeſt of theſe Corpuſcles, that an indefinite Number of them muſt be contained in every cubic Inch of Matter. Wherefore, if we expreſs the Exceſs of Attraction in any ſingle Corpuſcle, by any finite Quantity, how ſmall ſoever; the Sum of that Exceſs in all the Corpuſcles of a cubic Inch will be indefinitely great. The Sum of the Repulſions of all the Surfaces ballances this extraordinary Force of Attraction, and is conſequently as great. Compreſs them ſtill further by an external Force, and this Repulſion will be vaſtly increaſed upon every little Diminution of the containing Space; becauſe it increaſes much faſter, than in the reciprocal Ratio of the Diſtances of the Centers of the Corpuſcles. *Prop.* 42. *Corol.* 3. Hence we may conclude, that a very ſtrong Force muſt be required to make a very ſmall Compreſſion. And after all it will be next to impoſſible to demonſtrate, whether ſuch Compreſſion is real or not: For whatever Machinery we make uſe of in trying the Experiment, the Materials of which it is compoſed will give way, more or leſs, and leave us ſtill in Doubt.

## PROP. XLVI.

Neutral Corpuſcles will be repelled by repellent Corpuſcles, and attracted by the attracting ones.

In both Caſes their Tendency to recede from each other will be as the Quantities of repelling Matter; and their Tendency to approach will be as the Quantities of attracting Matter: But the Sum of the repellent Matter is the greateſt in the firſt Caſe; and that of the attracting in the ſecond: Therefore in the firſt Caſe they will repel, and in the ſecond attract.

## PROP. XLVII.

Attracting and repelling Corpuſcles will either attract or repel, or be neutral in regard to each other, according as the

Sizes of each are greater or leſs; and according to their Diſtances from each other.

*Firſt*, *In Point of Contact:* If both the attracting and repelling Corpuſcles are the ſmalleſt of their Kinds, they will repel each other.

For in that Caſe the Exceſs of repellent Matter would be very great in the repelling Corpuſcles; and the Defect of it very little in the attracting ones. *Prop.* 41, and 44. So that the Sum of it in both would exceed the Sum of the attracting Matter.

*Secondly*, If the Corpuſcles were the largeſt of their Kinds, the repelling ones would exceed very little in repelling Matter; and the attracting ones would have little united to them. On which Account, the attracting Principle would prevail.

*Thirdly*, For the ſame Reaſons it muſt follow, that in ſome of the intermediate Sizes the Exceſs of Repulſion in the repellent Corpuſcles will juſt ballance the Defect of it in the attracting ones. In which Caſe they will be neutral in reſpect of each other.

*Fourthly*, If the attracting and repelling Corpuſcles are not in Contact, but at any conſiderable Diſtance, their mutual Action upon each other will produce a weaker Kind of Repulſion.

For an attracting Corpuſcle will have the Defect of repellent Matter on its Surface made up by an Atmoſphere condenſed round it. *Prop.* 39. *Corol.* 3. So that the Corpuſcle and its Atmoſphere together will contain an equal Quantity of attracting and repelling Matter; and a repelling Corpuſcle placed without the Limits of its Atmoſphere will be repelled, for the ſame Reaſon as in the Caſe of neutral Corpuſcles. *Prop.*46. But this Repulſion will be of a weaker Kind than if the repellent Matter was fixed; becauſe that Part of it, which is in Form of Atmoſphere, will recede in Part backwards, in Proportion as the Corpuſcles are brought nearer.

*Fifthly*, If the attracting Corpuſcle, on Account of its Largeneſs, has a very extenſive Atmoſphere, and a repelling

Corpuſcle be brought ſo near as to enter within the Limits of that Atmoſphere, it will then begin to be attracted.

Becauſe the further it penetrates within the Atmoſphere, the fewer repellent Particles will be betwixt the two Corpuſcles; and even thoſe that are united to the repellent Corpuſcle will begin to be determined towards the Center of the attracting one, with a Force increaſing in the reciprocal Ratio of the Diſtances, *Prop.* 33. and in Contact they will cohere together with a Force proportionable to the Exceſs of their attracting Matter directly, and the Diſtances of their Centers reciprocally.

## PROP. XLVIII.

All the various Degrees of Coheſion, that are found amongſt Bodies, will naturally ariſe from the different Sizes of their conſtituent Corpuſcles; and one ſimple, uniform Kind of Attraction and Repulſion, ſuch as hath been already explained.

§. 1. All the primary Corpuſcles of Bodies are compounded of attracting and repelling Matter. *Prop.* 36. The ſmalleſt Corpuſcles in Nature are ſuch as mutually repel each other. *Prop.* 39. *Corol.* 2. and *Prop.* 40. A ſufficient Number of ſuch repellent Corpuſcles, collected together, will compoſe a Fluid in all Reſpects reſembling pure elementary Air, at leaſt as far as we are able to judge from the known Properties of that Element. The common Air, indeed, of our Atmoſphere is a Fluid far leſs ſimple and homogene than what is here ſuppoſed: It is rather a Chaos of all the Subſtances in Nature, and is on that Account capable of producing a great Variety of *Phænomena*, that can in no wiſe be aſcribed to ſo ſimple a Cauſe. If therefore we would make a juſt Compariſon betwixt the common Air and our repellent Corpuſcles, we muſt ſuppoſe them alſo mixed with the ſame Variety of other Subſtances. Our repellent Fluid will be compreſſable and perfectly elaſtic, the Diſtance of its Particles will render it extremely rare and pellucid, and their Diſtance and Smallneſs together will make it exceed all other Fluids in Levity. If the Air is really more elaſtic at different Heights of the Atmoſphere, we need only conceive its Particles of different

Sizes, to account for it. The ſmalleſt, and conſequently the lighteſt, will have moſt Elaſticity, *Prop.* 41. Thoſe by the Laws of Hydroſtaticks will riſe higheſt, and *vice verſâ* the groſſeſt and leaſt elaſtic will occupy the loweſt Part of the Atmoſphere.

§. 2. The neutral Corpuſcles are the next in Magnitude: Theſe will neither attract nor repel, except in Point of Contact. Such Corpuſcles would compoſe a Fluid of much greater Denſity than the Air, void of Tenacity, and compreſſable. *Prop.* 42. We do not find in Nature any Fluid exactly correſponding with this in all its Properties: So that if ſuch a one does really exiſt, it muſt be diſguiſed by ſome other Circumſtances. Water is a Fluid that ſeems moſt likely to wear this Maſk. Pure elementary Water may be both compreſſable, and void of Tenacity: But all that we are acquainted with is far from being pure, and the Mixture of other Subſtances may very well account both for its Tenacity and Incompreſſability. If neutral Corpuſcles are mixed with attracting ones, the Compoſition thence ariſing will be a Fluid, in which the attracting Principle will be more prevalent than that of Repulſion. In this Caſe the neutral Corpuſcles will be attracted by the attracting Corpuſcles, *Prop.* 46. and taking the Place of their Atmoſpheres, be condenſed round them, with a Force proportionable to the Exceſs of their Attraction. The ſeveral Aggregates, thus produced, containing more attracting than repelling Matter, will be determined towards each other, with a Force likewiſe proportionable to the Exceſs of Attraction: Whence a Fluid will be formed, the Attraction of whoſe Parts among themſelves will cauſe a moderate Degree of Tenacity, like that of Water. It will alſo be incompreſſable, for the ſame Reaſons that are given in the ſecond *Corollary* to *Prop.* 45. For its Parts are in Contact, and are already compreſſed by their own Force of Attraction. Oils, Salts, Earths and Minerals of all Kinds are compoſed, in Part at leaſt, of attracting Corpuſcles; ſome of which make always a Part of Water, even in its pureſt State. The Air, indeed, inſinuates itſelf into it, but does not make any neceſſary Part of its Compoſition. When Water is purged of Air by the Air-Pump, or Boiling, its Properties continue the ſame. The chief Reaſon of its mixing with Water ſeems to be this: The ſuperincumbent Atmoſphere preſſes with its whole Weight upon its Surface; the Particles of Air contiguous to the Surface are more repelled by thoſe of their own Kind than by the Particles of Water, and therefore enter the Subſtance of it, to recede from the greater Repulſion. After this Entrance they will remove to as great a Diſtance as poſſible from each other, and diſperſe themſelves equably throughout the containing Fluid. Take off the Preſſure of the Atmoſphere, and they emerge again, which ſhews that they are not united to the Particles of Water by any Bond of Coheſion: Therefore the Repulſion that would be between the Corpuſcles of Air and Water, *Prop.* 46. would not prevent the Air from inſinuating itſelf into the Body of that Fluid. Hence we ſee the Reaſon of the great Tranſparency and Fluidity of Water, and why its ſpecific Gravity ſo much exceeds that of the Air. The aqueous Corpuſcles are never in real Contact with each other; but leave a ſufficient Space interſperſed for the eaſy Tranſmiſſion of the Rays of Light. They roll over one another without any Impediment to their Motion, but a ſmall Degree of Tenacity, and their *Vis Inertiæ*. Being both larger, and cloſer together than the Corpuſcles of the Air, they muſt neceſſarily produce a Fluid of greater ſpecific Gravity.

§. 3. The attracting Corpuſcles remain only now to be examined; and it will not be difficult to find what Name to claſs them under. Let the Size of thoſe Corpuſcles be greater or leſs, they will mutually attract each other; and (unleſs they be intermixed with repelling or neutral Corpuſcles) their Adheſion in Point of Contact will give them the Properties of a ſolid Body. Indeed the ſmaller theſe Corpuſcles are, the leſs will their Force of Coheſion be; but the ſmalleſt will cohere in ſome Degree, and that ſmall Coheſion will produce but a leſs Degree of Hardneſs. It will be very different from what has been ſhewn to conſtitute Fluidity in Water:

ter: In that, the attractingCorpuſcles are each ſurrounded with others, which do not at all attract, but are only condenſed round them by their Attraction, and ſerve the ſame Purpoſe as a Multiplicity of Wheels in a Machine; which by their bearing one upon another diminiſh the Friction almoſt *ad infinitum*. But here, each Corpuſcle adheres with ſome Degree of Force to all thoſe that are in Contact with it; and how ever ſmall that Force may be in one ſingle Corpuſcle, yet in ſuch a Number as muſt be contained in a Body of a ſenſible Magnitude, it will amount to ſomething conſiderable. Wherefore ſince all attracting Corpuſcles, of whatever Size, agree in this Property of Solidity, I think they may properly enough be all included under the general Name of Earth. Attracting Corpuſcles of different Magnitudes will produce Bodies of as different Degrees of Hardneſs and Denſity; and if the conſtituent Corpuſcles of Bodies were homogene, the various Kinds of Bodies would not be more in Number than the various Magnitudes of attracting Corpuſcles. And even in this Caſe, there might be produced almoſt an infinite Variety. But theſe Corpuſcles are never found in Nature unmixed with Air, or Water, or both. What an endleſs Diverſity of Subſtances muſt neceſſarily ariſe from ſuch a Combination! If the Elements of Air and Earth both contain an indefinite Series of Corpuſcles of different Sizes, the various Mixtures that may be made of thoſe two alone, will be much more indefinite. Join to theſe the Element of Water, and this Variety will be immenſely increaſed.

§. 4. If the ſmalleſt of the attracting Corpuſcles are united to a ſmall Quantity of neutral ones, juſt enough to ſurround and cover their Surfaces, a Fluid will be thence produced of much greater Tenacity than Water, and of greater ſpecific Gravity. For theſe Corpuſcles being ſuppoſed the ſmalleſt of their Kind, their Force of Attraction will not much exceed their repulſive Force: Wherefore, if they are combined with as many neutral Corpuſcles as will cover their Surfaces, their Contact and Coheſion will be ſufficiently prevented to leave them in a fluid State; and the Exceſs of their Attraction will ſuffice to produce a conſiderable Degree of Tenacity, and to bring the Parts of this Fluid cloſer together than thoſe of Water. On which Account, and alſo becauſe of the greater Size of its Corpuſcles, it will exceed Water in ſpecific Gravity. This Fluid will imbibe a much greater Quantity of Air than will be admitted by pure Water, becauſe it contains more attracting than repelling Matter. In Water, the compound Corpuſcles being neutral, the Corpuſcles of Air contiguous to its Surface will be repelled by them, tho' with leſs Force than by thoſe of their own Kind. *Prop.*46. Wherefore thoſe which penetrate that Fluid, in ſo doing, are only determined to that Quarter where there is leaſt Repulſion, and conſequently leaſt Reſiſtance: But the Fluid under our preſent Conſideration has leſs Repulſion than Water, and will therefore give leſs Reſiſtance to the Air in penetrating its Subſtance. Its greater Tenacity will, indeed, be rather an Impediment to the Air's Admiſſion, but when admitted will retain it ſo much the ſtronger. It will imbibe Air, till ſuch time as the Repulſion of that which is already entered, and the Fluid's Tenacity together, are ſufficient to reſiſt the Effort made by the Air's Weight and Spring to introduce itſelf. After which, the Air will be condenſed upon its Surface; the Repulſion on the Side of the Fluid being ſtill leſs than that of the Particles of Air amongſt themſelves: So that the latter will ſtill preſs in ſome Degree towards the former, though not with Force ſufficient to enter. The Exceſs of Attraction in the Fluid will alſo conſpire in condenſing the Air on its Surface. The Quantity of Air imbibed by this Fluid will very much increaſe its Volume: For as it conſiſts of attracting Corpuſcles, ſurrounded by neutral ones, a Quantity of repellent Corpuſcles being interſperſed amongſt them, muſt very much dilate them; becauſe neutral and repellent Corpuſcles repel each other. On this Account its ſpecific Gravity will be generally leſs than that of Water; though if it were to be found unmixed with Air it would be greater. Its leſs ſpecific Gravity will make it ſwim upon Water; for which and ſome other Reaſons it will not eaſily mix with that Element. Water, indeed, is already ſuppoſed one Part of its Compoſition; notwithſtanding which, it will be difficult for more to inſinuate itſelf among its component Parts. The Air that is plentifully mixed with it, and alſo ſpread over its Surface, will not only hinder thoſe Fluids from attracting, but even make them repel each other: For Air repells Water, *Prop.* 46. The Tenacity likewiſe of this Fluid will hinder its mixing with Water; which cannot be effected without a Separation of its Parts. Theſe Properties very well agree with the known Properties of Oils. If in ſome Circumſtances they are found to differ, that Difference may be very well accounted for by the Mixture of various other Subſtances. Oils are never found in the common Courſe of Nature unmixed with a greater or leſs Proportion of Salts, and a groſſer Kind of Earth. This is probably the Reaſon why ſome are ſpecifically heavier than Water; as doubtleſs it is the Cauſe of a great Diverſity in the Conſiſtency, Taſte, Smell, Colour and other Properties of that Fluid. Theſe ſmalleſt attracting Corpuſcles, when not ſurrounded by neutral ones, will form a Subſtance vaſtly different from Oil: It will appear, when we come to treat of Fire, to be what *Stahl* and other Chemiſts have called the *Phlogiſton*, the moſt ſubtle Earth in Nature.

§. 5. If we conſider the Size of attracting Corpuſcles as ſtill larger, we ſhall have an Idea of the univerſal Acid, the Baſis of all Salts; to which this Acid bears the ſame Relation, as the *Phlogiſton* does to Oils: For they have as much Analogy as can be expected in Things eſſentially different. They are both of them very fixed in the Fire, provided they be contained in cloſe Veſſels, and have neither Air nor Water joined with them to make them volatile. When not united to groſſer Earth, and expoſed to the open Air, they are the moſt volatile Subſtances yet known, except Water and Air itſelf; and ſuch Compounds as contain one or both of them, and are made volatile by them. Surround their Corpuſcles with Water, the one becomes Oil, the other the Acid of Vitriol: Join to this Oil different Proportions of

Salts and Earths, you will have generated Oils various in Smell, Taſte, Colour, Spiſſitude, Weight, *&c.* Likewiſe Balſams, Gums, and Reſines. For Corpuſcles of a larger Size than thoſe that conſtitute Oils, will have a greater Proportion of attracting Matter, *Prop.* 44. and therefore when mixed with them, the Proportion of attracting Matter will be greater in the Compound, than it was in Oils ſingly; and by how much the attracting Principle in any Compound prevails more than the repellent, by ſo much the ſtronger will the Coheſion among the ſeveral conſtituent Parts be, *cæteris paribus*; the Effect being always proportionable to the Cauſe. A like Increaſe of Coheſion, but in a greater Degree, will happen to the vitriolic Acid from a Mixture of earthly Corpuſcles, of a larger Size, and conſequently more attracting. The acid and earthy Particles will run together with Violence; and after they have ſeparated themſelves from the ſuperfluous Air and Water before united with them, they will form one Concrete; whoſe Parts will adhere ſo ſtrongly, as to conſtitute a Solid. Hence Salts will be generated in a ſolid Form of various Kinds, according to the Nature of the Earth with which they are combined.

§. 6. Corpuſcles of a greater Magnitude than thoſe laſt mentioned, to conſtitute the univerſal Acid, will have a ſtill greater Force of Attraction. *Prop.* 44. And by conſidering the Sizes, in a regular Series, one exceeding another, there can be no Degree of Coheſion amongſt the conſtituent Parts of Bodies that may not be thence produced, whether they be Earths, Stones, Metals, or other Minerals. And this Coheſion will be differently modified by the different Combination of Air, Water, Oils, Salts, Earths, and Metals, in an infinite Variety: So that, I think, I have clearly proved, that all the various Degrees of Coheſion that are found amongſt Bodies, will naturally ariſe from the different Sizes of their conſtituent Corpuſcles, and one ſimple, uniform Kind of Attraction and Repulſion.

*Note*, The Doctrine I have interſperſed through the whole Courſe of this Demonſtration, for the Sake of illuſtrating the Force of it by an Application to Facts, may, in ſome Caſes, be erroneous, without leſſening the Truth of the Propoſition; the Evidence of which is ſufficiently clear, without any Reference to Facts, provided the Propoſitions referred to in the Demonſtration be true. Even ſuppoſing the Principles I go upon to be out of Doubt, it would be the higheſt Preſumption in me to think myſelf capable of making a right Application of them to all the *Phænomena* in Nature. The ſame Principles in the Hands of a Perſon of greater Capacity, and more extenſive Knowledge than myſelf, would doubtleſs be much better applied; and even then come infinitely ſhort of the Truth. They would ſtill be in the Hands of a finite Being, that ſees as through a Glaſs, darkly: Whereas the real Application of theſe Principles in Nature is conducted by a Being of infinite Wiſdom and Power.

### COROL. I.

It follows, from what hath been ſaid of the Nature of Coheſion, that all Bodies, whether ſolid or fluid, are a Compound of attracting and repelling Matter.

### COROL. II.

Bodies in which the attracting and repelling Matter are equal, will neither attract nor repel.

### COROL. III.

Such Bodies as contain more attracting than repelling Matter in their Compoſition, will attract with a Force proportionable to the Exceſs of attracting Matter; and *vice verſâ.*

### COROL. IV.

The attracting Force of Bodies will increaſe in Proportion as their repulſive Force decreaſes; and *vice verſâ.*

### PROP. XLIX.

If two or more attracting Bodies cohere together, and a Force be applied to ſeparate them, the Reſiſtance to the ſeparating Force will increaſe, the farther they are ſeparated from each other, till they come to a certain Diſtance; after which it will decreaſe.

Attracting Corpuſcles approach each other with an increaſing Force, till they come ſo near, that the Repulſion at their Surfaces begins to counter-act their Force of Attraction; after which their Attraction becomes weaker and weaker, the nearer they approach, being more and more deſtroyed by the contrary Force of Repulſion; and at a certain Diſtance the Repulſion at their Surfaces becomes ſo ſtrong, as to equal and quite deſtroy the attracting Force: For equal and contrary Forces mutually deſtroy each other. In this Point therefore the attracting Corpuſcles are at reſt; *Prop.* 42. and *Corol.* 3. and are in phyſical Contact with each other. Now 'tis evident, that if in their Approach the Force of Attraction increaſed, till they came to a certain Diſtance from each other, and then gradually decreaſed, till in Contact it was nothing; in removing them back again to the ſame Point, the Attraction will be gradually reſtored, or increaſe, and beyond that Point it will decreaſe again: But the Reſiſtance to a ſeparating Force at different Diſtances will be as the Force of Attraction at thoſe Diſtances; therefore the Reſiſtance will increaſe, the further they are removed from each other, till they come to a certain Diſtance; after which it will decreaſe.

## COROL.

This Law of Coheſion very well explains the Cauſe of Elaſticity in Bodies. Every Kind of Elaſticity depends either upon the Spring, with which Bodies reſtore themſelves when their Parts are preſſed together; or when ſtretched or drawn out to a greater Diſtance from each other; or when ſome Parts are ſtretched, whilſt others are preſſed. When the Parts of Bodies are preſſed together, the Repulſion at the Surfaces of each component Corpuſcle will re-act as a Spring. When they are drawn out to a greater Diſtance from each other, they will contract and reſtore themſelves again by this Law, with a Force proportionable to the Degree of Tenſion. But if the diſtending Force be ſo great as to draw them beyond the Diſtance at which the Repulſion of Surfaces begins to take place, their greateſt Force of Attraction will be then overcome, and an entire Separation muſt enſue: As is the Caſe when the Strings of muſical Inſtruments are broke, by being over-ſtretched. Both Cauſes ſeem to take place in common Springs; for when they are bent, the Parts on the concave Side are compreſſed, and thoſe on the convex Side are diſtended.

### PROP. L.

All Bodies whatſoever, whether ſolid or fluid, muſt contain more Pores than ſolid Parts.

The Truth of this Propoſition has been ſufficiently proved by moſt of the Philoſophers of this and the laſt Century, from Facts and Experience: Yet it was not ſo eaſy to conceive, how it could be true in all Caſes; whilſt they ſuppoſed the conſtituent Parts of Bodies in actual Contact. But ſince it is evident from *Prop.* 45. *Corol.* 1. that the Corpuſcles, of which Bodies are compounded, never come in actual Contact at all, I think all thoſe Difficulties are removed, and the Truth too clear to require any further Demonſtration.

### COROL. I.

Therefore all Bodies, how denſe ſoever, will be capable of containing betwixt their component Corpuſcles more or leſs of the repellent Fluid, in Proportion to the Number and Size of their Pores.

### COROL. II.

There will be always more Pores to admit, than ſolid Parts to reſiſt the free Ingreſs and Regreſs of the repellent Fluid.

### PROP. LI.

The repellent Matter will be condenſed partly in the Pores of ſolid Bodies, and partly upon their Superficies in Form of Atmoſphere.

It muſt be condenſed either in the Pores, or on the Superficies, or both. *Prop.* 32. and 34. *Corol.* 1. It cannot be condenſed in the Pores only; becauſe it would then be denſer in the Pores than in the Space immediately ſurrounding them, and not being confined by an equal Preſſure from without, they muſt be determined outwards, to the Part where there is leaſt Preſſure. For the ſame Reaſon, if the Condenſation was only on the Superficies, they would be determined into the Pores: Therefore the Condenſation muſt be both in the Pores and on the Superficies.

### COROL.

The repellent Matter will be always denſer in the Pores and on the Superficies of ſolid Bodies, than in other Parts of Space.

### PROP. LII.

In ſolid Bodies of equal Dimenſions the Space occupied by the Pores will be greater, *cæteris paribus*, in Proportion as the component Corpuſcles are leſs; and *vice verſâ*, where the component Corpuſcles are largeſt, the Space occupied by the Pores will be leaſt.

In Bodies of equal Dimenſions the whole containing Spaces muſt be equal; and the leſs the component Corpuſcles are, the leſs Space they will occupy themſelves, *cæteris paribus:* The reſt will be Pores; and *vice verſâ.*

### COROL. I.

This will be the Caſe, ſuppoſing the Number of Corpuſcles the ſame in each Body: But ſince the Number of Corpuſcles are always greater in Bodies where they are larger, and conſequently much denſer, *Prop.* 45. the Space occupied by the Pores will, on that Account, alſo be greater where the Corpuſcles are ſmall, than where they are large; and *vice verſâ.*

### PROP. LIII.

In Bodies of equal Dimenſions, thoſe whoſe Corpuſcles are largeſt and denſeſt, will have the greateſt Quantity of repellent Matter condenſed upon their Surfaces, in Form of Atmoſphere.

The larger the Corpuſcles are, the more repellent Matter will be attracted by them; which will all be either condenſed in the Pores, or upon the Superficies in Form of Atmoſphere.

ſphere. *Prop.* 51. The Capacity of the Pores is leaſt, where the Corpuſcles are largeſt and denſeſt. *Prop.* 52. and *Corol.* and the leſs the Pores can contain, the more muſt be condenſed upon the Superficies in Form of Atmoſphere.

*Note* 1. In my Reaſoning on Bodies in general, I conſider them as quite homogene and uniform, both in their Pores and ſolid Parts; free from thoſe Cavities and Depreſſions, and other Inequalities uſually found in the Texture of natural Bodies. A proportionable Allowance muſt therefore be always made in the Application of theſe Truths to Facts.

*Note* 2. The repellent Fluid condenſed on the Surfaces of ſolid Bodies in Form of Atmoſphere, I call their repellent Atmoſphere, to diſtinguiſh it from their true Atmoſphere; which is Air in like Manner condenſed.

## PROP. LIV.

If the Pores of a Body are large enough to admit the Air, or a denſer Fluid, the repellent Matter in the Pores, and on the Surface, will give place to the denſer Fluid.

All other Fluids beſides the repellent one, conſiſt of Corpuſcles, that are partly repellent, and partly attracting Matter: The repellent Matter of theſe Corpuſcles will be equally determined towards the Surfaces, and into the Pores, with as much Force as the Particles of the repellent Fluid, being in all Reſpects the ſame. The attracting Matter of the ſame Corpuſcles will be attracted in Proportion to the Quantity of it. Therefore the repelling Matter of the Corpuſcles being determined towards the Surfaces and into the Pores, with a Force equal to that of the repellent Fluid, and the Force of the attracting Matter conſpiring, the Corpuſcles muſt be determined towards the Surfaces and into the Pores with more Force than the Particles of the repellent Fluid; which muſt conſequently give place to the ſtronger Force.

## PROP. LV.

Water will be attracted by the Surfaces and Pores of ſolid Bodies with more Force than Air; and, provided the Pores are large enough, will enter them, and drive out the Air.

Water has a greater Force of Attraction than Air, having more attracting Matter; and will therefore be ſtronger attracted both by the Surfaces, and into the Pores, provided the Pores are large enough to admit the Corpuſcles of Water, and the Attraction ſtrong enough to overcome its Tenacity: Which will always be the Caſe in ſolid Bodies, becauſe their component Corpuſcles are larger and more attracting than thoſe of Water: It will therefore enter the Pores, and drive out the Air.

## COROL.

For the ſame Reaſons, ſuch Fluids as contain more attracting Matter than Water, will be ſtronger attracted by the Surfaces and into the Pores, provided their Tenacity is not greater than that of Water, and the Pores be large enough to receive them.

## PROP. LVI.

If the Pores are wholly or in Part void of Air, and large enough to admit Water, the Water will ruſh in with more Violence, in Proportion as there is a leſs Quantity of Air to be removed.

For if the Pores be already filled with Air, the Water cannot drive it out without acting upon it; and ſince Action and Re-action are mutual, the Air will act upon the Water, and retard its Motion: But when the Pores are void of Air, it enters without any Impediment, and is likewiſe aſſiſted by the Weight of the Atmoſphere.

## COROL.

The Cavities of capillary Tubes cannot contain ſo much Air as would have been condenſed upon the ſame Quantity of Surface on the external Parts of the Glaſs; and the ſmaller the Cavities are, the leſs will be the Quantity contained in Proportion to the Surface: So that Water, in entering the Cavities of capillary Tubes, will have a leſs Proportion of Air to remove in thoſe of a ſmall Diameter; and will conſequently ruſh in with more Violence. The Force of Attraction will be, *cæteris paribus*, as the attracting Surfaces;

which will be as the Diameters of the Tubes. But the Cavities of the Tubes will be as the Squares of the Diameters, *cæteris paribus*; therefore the Quantity of contained Air will decreaſe in the duplicate Ratio of the Diameters: But the Force that is to drive it out will only decreaſe in the ſimple Ratio of the Diameters.

## PROP. LVII.

The Denſity of the repellent Atmoſpheres, at different Diſtances from the Center of the Bodies they ſurround, will be reciprocally as thoſe Diſtances.

The repellent Matter will be determined towards the Space occupied by the Body, with a Force decreaſing in the reciprocal Ratio of the Diſtances. *Prop.* 33. And ſince the Denſities will be as the condenſing Force, they will likewiſe be in the reciprocal Ratio of the Diſtances. If the repellent Matter be attracted by the attracting Matter, the Denſity of the repellent Atmoſphere will not be altered thereby; for the Attraction will be as the Quantities of Matter multiplied by the Diſtances reciprocally; and the Quantity of Matter that compoſes the repellent Atmoſphere will be very ſmall, and ſome of it at a very great Diſtance from the Center of the attracting Body; conſequently the Attraction of it muſt there be quite inconſiderable, and the Condenſation ariſing from thence will be very little: But if it were more than can reaſonably be ſuppoſed, the abſolute Denſity would be ſtill the ſame; becauſe in Proportion to the Condenſation ariſing from Attraction, the other would be diminiſhed, ſince the Principle on which the other takes place is the Defect of repellent Matter towards the Space occupied by the Body; which Defect will be leſſened in Proportion to the Quantity drawn thither by the Body's Attraction. Wherefore the abſolute Denſity muſt ſtill remain exactly in the reciprocal Ratio of the Diſtances from the Center of the Body.

## PROP. LVIII.

If the whole Infinity of Space was filled with a repellent

Fluid, and only one ſolid Body exiſted in it, the repellent Atmoſphere of that Body would extend to a greater Diſtance than can be aſſigned.

The Denſity of the repellent Atmoſphere would increaſe in the ſimple Ratio of the Diſtances reciprocally, by the laſt: Therefore at double the Diſtance from the Center of the Body, the Denſity will be $\frac{1}{2}$, at triple the Diſtance $\frac{1}{3}$, at quadruple the Diſtance $\frac{1}{4}$, and ſo on *ad infinitum*. Wherefore at any aſſignable Diſtance the Denſity will be ſomething more than at a Diſtance ſtill greater; and conſequently the repellent Atmoſphere will extend to a greater Diſtance than can be aſſigned.

## PROP. LIX.

If two or more Bodies be ſuppoſed to exiſt, and be placed at a Diſtance, their repellent Atmoſpheres will mutually put Bounds to each other on thoſe Sides which mutually reſpect each other.

The repellent Fluid cannot both increaſe and decreaſe in Denſity at the ſame Time, and in the ſame Place; therefore on thoſe Sides which mutually reſpect each other, there muſt be a certain Diſtance, at which the repellent Atmoſphere of one Body will ceaſe to decreaſe in Denſity, and that of the other begin to increaſe; that is, one will end where the other begins. Therefore they will mutually put Bounds to each other, on the Sides which mutually reſpect each other.

## PROP. LX.

Within the repellent Atmoſphere of a Body the Force of Repulſion decreaſes directly as the Diſtances decreaſe from the Center.

The Quantities of repellent Matter at different Diſtances will be in the compound Ratio of the Spaces it takes up, and of the Denſities. The Spaces occupied by the repellent Matter, at different Diſtances from the Center of the Body, are in the direct Ratio of the Cubes of thoſe Diſtances, and the Denſities are as the Diſtances reciprocally, *Prop.* 57. which two Ratio's compounded are equal to the direct

Ratio of the Squares of the Diſtances. Therefore the Quantities of repellent Matter at different Diſtances within the repellent Atmoſphere, will be as the Squares of thoſe Diſtances directly: But the Force of Repulſion, at different Diſtances, will be in a Ratio compounded of the direct Ratio of the Quantities of repellent Matter, and the reciprocal Ratio of the Diſtances; that is, a Ratio compounded of the direct Ratio of the Squares of the Diſtances, and the reciprocal Ratio of the Diſtances, equal to the direct Ratio of the Diſtances: Conſequently the Force of Repulſion, at different Diſtances within the repellent Atmoſphere, muſt be in the direct Ratio of thoſe Diſtances, and decreaſe directly as the Diſtances decreaſe.

## PROP. LXI.

At different Diſtances within the repellent Atmoſphere of a Body, the Force of Attraction will be in the reciprocal Ratio of the Squares of thoſe Diſtances from its Center.

If the Repulſion was the ſame at all Diſtances, the Force of Attraction would be ſimply in the reciprocal Ratio of the Diſtances: But the attracting Force of Bodies increaſes in Proportion as the repulſive decreaſes, *Prop.* 48. *Corol.* 4. and the repulſive Force decreaſes as the Diſtances decreaſe, by the laſt: Wherefore the attractive Force will increaſe as the Diſtances decreaſe, on Account of the diminiſhed Repulſion, as well as on Account of the Decreaſe of Diſtance. But the two Ratio's compounded produce the reciprocal Ratio of the Squares of the Diſtances; *e. g.* At half the Diſtance the Force of Attraction is equal to 2, from the Decreaſe of Diſtance, the Repulſion remaining the ſame: But if at half the Diſtance the Repulſion will be but $\frac{1}{2}$, the Attraction will have double the Force that it would have if the Repulſion was the ſame. The whole Force therefore will be $2 \times 2 = 4$. In like Manner, at $\frac{1}{3}$ of the Diſtance, the Force of Attraction is $3 \times 3 = 9$; and ſo on.

### COROL. I.

The Attraction betwixt the Sun and each of the heavenly

Bodies revolving round it, will be in the reciprocal Ratio of the Squares of their Diſtances from its Center: For the repellent Atmoſphere of the Sun is bounded by thoſe of the Fixed Stars ſurrounding it. *Prop.* 59. Therefore its Extent will be ſufficient to contain not only the whole Sphere of *Saturn*, but the utmoſt Bounds to which any of the Comets may be ſuppoſed to go. And all the Planets and Comets, ſurrounded with their repellent Atmoſpheres, are within the Limits of the Sun's repellent Atmoſphere; and conſequently are attracted towards its Center, with a Force increaſing as the Squares of the Diſtances decreaſe.

### COROL. II.

For the ſame Reaſon, all the ſecondary Planets, revolving within the repellent Atmoſphere of their Primaries, muſt gravitate towards its Center. The Moon and all other Bodies within the Earth's repellent Atmoſphere, towards the Center of the Earth; and univerſally every Body, within the repellent Atmoſphere of another, will gravitate towards the Center of that Body.

### COROL. III.

Therefore the Attraction of Gravity, as well as that of Coheſion, decreaſes in Reality as the Diſtances increaſe, tho' it ſeems to act in the reciprocal Ratio of the Squares of the Diſtances, on Account of having the repulſive Principle compounded with it. So that theſe two Attractions decreaſeing in different Ratio's, is no Hindrance to their being eſſentially the ſame.

### PROP. LXII.

Beſides the repellent Atmoſpheres ſurrounding ſolid Bodies, they will likewiſe have an Atmoſphere of Air. This I ſhall call their true Atmoſphere, or ſimply their Atmoſphere.

The Earth has evidently a very extenſive Atmoſphere, and Experiments ſeem to ſhew, that all ſolid Bodies upon the Earth have Air condenſed round them, more or leſs, and likewiſe adhering to their Surfaces. It is not neceſſary to enumerate the ſeveral Facts that have been referred to in

Confirmation of this Doctrine, ſince they are ſufficiently known. It will be more to our Purpoſe to ſhew, from what has been already demonſtrated, the Cauſe of this Condenſation, and to prove the Neceſſity of its being univerſal. It follows, from *Prop.* 51. that all ſolid Bodies muſt have a repellent Atmoſphere. The Air preſſes upon the Surfaces of all Bodies, and is contiguous with them; it therefore enters within the repellent Atmoſpheres of Bodies, and muſt conſequently be attracted towards their Centers, with a Force decreaſing in the reciprocal Ratio of the Squares of the Diſtances. *Prop.* 61. Thoſe Particles of Air that are neareſt the Surface will be united in Contact with it; and cohere with a Force, that will be in a Ratio compounded of the direct Ratio of the Exceſs of attracting Matter in the Body, and of the reciprocal Ratio of the Diſtances from its Center. *Prop.* 47. §. 5. Wherefore the Air will be united to the Surfaces of all ſolid Bodies, and as far as the repellent Atmoſphere reaches, form an Atmoſphere round them, till the Exceſs of repellent Matter in the Air, added to the repellent Atmoſphere interſperſed among its Particles, is ſufficient to ballance the Force of Attraction in the Body. Now if the Earth, and all the ſolid Bodies upon it, have their reſpective Atmoſpheres, it is reaſonable to conclude, that the Planets and other heavenly Bodies are not without them: The Sun has, apparently, a very large Atmoſphere, and the Comets can hardly be ſuppoſed to be without, when we conſider the Appearance they make. The Exiſtence of the Moon's Atmoſphere is rendered more than probable, from many aſtronomical Obſervations; nor do I know any concluſive Argument that can be brought to prove, that any of the Planets are without: So that we ought to conclude this Propoſition univerſally true, till Reaſons can be found to evince the contrary.

## COROL.

The Surfaces of all ſolid Bodies have Air in Contact with them, and cohering to them; and that even *in vacuo:* For the Preſſure of the external Air may very much increaſe the

Coheſion of Air to the Surfaces of ſolid Bodies; yet as it is not the whole Cauſe of that Union, the Abſence of it will not produce a Separation.

## PROP. LXIII.

The repellent Atmoſpheres of ſolid Bodies upon the Surface of the Earth, will have their Places ſupplied by the Preſence of their true Atmoſpheres; and no more of them will remain, than what is condenſed in the Interſtices betwixt the Particles of Air.

The Particles of Air conſiſt of a greater Proportion of repellent than attracting Matter, *Prop*. 48. and therefore, the more of them are condenſed upon the Surfaces of Bodies, and united to them, the more will the Exceſs of Attraction in each Body be ballanced by the Exceſs of Repulſion in its Atmoſphere. The Air will be condenſed till the Increaſe of Repulſion ariſing from that Condenſation is equal to the Exceſs of Attraction, and the Body, together with its Atmoſphere, contains an equal Proportion of attracting and repelling Matter. Beyond the Limits of the true Atmoſphere, the attracting and repelling Forces will be *in equilibrio* with each other; and conſequently neither the Air, nor repellent Fluid, will have any Tendency there towards the Body. The repellent Atmoſphere therefore cannot extend beyond the Limits of the true one: But in the Interſtices betwixt the Corpuſcles, that compoſe the true Atmoſphere, it will be condenſed; and may be ſtill conſidered as a repellent Atmoſphere.

### COROL. I.

For this Reaſon there can be no Attraction of Coheſion betwixt ſolid Bodies, whilſt the Air is united to, and condenſed upon their Surfaces: But the Air being removed by the Application of a denſer Fluid, and the Bodies brought in Contact, they will cohere together.

### COROL. II.

The Air being united to the Surfaces of Bodies, thoſe Surfaces will repel each other when brought very near together.

COROL.

## COROL. III.

Where a ſufficient Quantity of Air or repellent Fluid cannot have Acceſs to the Surface of a Body to ballance the Force of Attraction, that Surface will be in an attracting State. The Surfaces of the internal Pores of all Bodies are in this State; and all Cavities whatſoever, whoſe Sides are ſo near as not to admit the Whole of their Atmoſpheres betwixt them. For Inſtance: The Cavities of capillary Tubes not having a ſufficient Capacity to contain all the Air or repellent Fluid that would be neceſſary to ballance the Attraction of their internal Surfaces, the Whole of thoſe Surfaces are in a State of Attraction. The ſmaller their Cavities are, the ſtronger will that Attraction be. Water will riſe to the greateſt Heights in Tubes of the ſmalleſt Diameter, though their Lengths be the ſame; which is owing to the attracting Surfaces acting upon the Water at a leſs Diſtance in narrower Tubes: For the Attraction will be in the reciprocal Ratio of the Diſtances at which the Surfaces act. The Diſtances of the Surfaces in Tubes of different Diameters, will be as the Diameters: Therefore the Force of Attraction will be in the reciprocal Ratio of the Diameters, *cæteris paribus*. But in Tubes of equal Diameters, and different Lengths, the longeſt will raiſe the Water to the greateſt Height, becauſe the Whole of the internal Surfaces are in a State of Attraction, and the longeſt Tubes have the moſt internal Surface, *cæteris paribus*.

## PROP. LXIV.

The true Atmoſpheres of the heavenly Bodies will no ways alter the general Laws of Gravitation.

The Earth and its Atmoſphere together can only be conſidered as one Body, in regard to Gravitation; becauſe the attracting and repelling Forces of both will act as from one common Center, and the Quantities of attracting and repelling Matter in both will continue the ſame at all Diſtances from the Sun. The ſame Reaſoning is equally true, when applied to the reſt of the heavenly Bodies: This however deſerves Conſideration, that the larger and denſer the Atmoſpheres are that ſurround the heavenly Bodies, in Proportion to their Magnitudes, the leſs will be the Force of their Attraction at all Diſtances; becauſe the more Air there is in the Compound, the more there will be of repellent Matter; and the more there is of repellent Matter, the leſs will be the Force of Attraction. From whence we may deduce the following Corollaries:

### COROL. I.

The Denſity of the heavenly Bodies may even increaſe in Proportion as their Magnitudes increaſe, provided their Atmoſpheres increaſe in a much greater Proportion; and yet their Force of Attraction may increaſe in a much leſs Proportion than that of their Magnitudes: So that we muſt not neceſſarily conclude the larger of the heavenly Bodies to be rarer than the leſs, becauſe they are ſpecifically lighter; unleſs we were ſure, that the ſmaller had as large Atmoſpheres as they, in Proportion to their Size. Certainly it is more conſiſtent with that beautiful Simplicity and Uniformity which is every where conſpicuous in the Works of the Creation, to ſuppoſe thoſe vaſt Bodies, the Sun, *Jupiter* and *Saturn*, to be much more denſe than either the Earth or Moon; and that their Atmoſpheres are proportionable to their Magnitudes in Extent. In which Caſe, the Quantity of Air contained in them will be much greater in Proportion to the Magnitude of their Bodies, than the Quantity contained in our Atmoſphere is, in Proportion to the Body of the Earth; becauſe their Atmoſpheres will be exceedingly more denſe than ours, both on account of their Heights, and the greater Force of Attraction that muſt belong to Globes of their Magnitudes.

### COROL. II.

The Denſity of the Moon may be leſs than that of the Earth, or any of the other Planets, notwithſtanding its Force of Attraction is proportionably greater, provided its Atmoſphere is proportionably leſs than theirs, in reſpect to the Quantity of Air contained in it.

*Quære.* May not this be one Reaſon why the Moon's Atmoſphere is ſo little viſible to us at this Diſtance?

## PROP. LXV.

If a Body, ſurrounded by its Atmoſphere, revolves round a larger, ſurrounded by another Atmoſphere, the two Atmoſpheres will mutually repel each other, with a Force increaſing as the Diſtances decreaſe.

The component Corpuſcles of both Atmoſpheres conſiſt of more repelling than attracting Matter, *Prop.* 48. §. 1. and conſequently the Force of Repulſion in both will exceed the Force of Attraction: Wherefore they will mutually repel each other, with a Force proportionable to that Exceſs; which Force will increaſe as the Diſtances decreaſe, by the general Law of Repulſion.

### COROL. I.

In Proportion to the Degree of this repulſive Force, the Atmoſphere of the revolving Body will recede from the Center of the other, and retreat more or leſs behind its own Globe.

*Quære.* May not the Atmoſphere of the Moon be in Part repelled by that of the Earth, towards that Side which is always turned from us? And may not this be another Reaſon why it is leſs viſible to us?

### COROL. II.

This Repulſion will be very conſiderable in the Atmoſpheres of the Comets: For it will become greater and greater, in Proportion to their nearer Approach to the Sun; becauſe it increaſes as the Diſtances decreaſe. Therefore at every Decreaſe of Diſtance, the Comet's Atmoſphere will more and more retreat to that Side of the Comet which is fartheſt diſtant from the Sun's Center. And ſince this Force will act in a Direction almoſt contrary to that of the projectile Motion of the Comet, the projectile Motion of its Atmoſphere will be more and more retarded thereby; and that Part of it which is moſt remote from the Comet, will leaſt conſpire with the Direction of the projectile Force, and alſo be left a great Way behind the Comet, on Account of the Retardation of its Motion. This ſeems to explain all thoſe remarkable *Phænomena* that appear in the Tails of Comets. The Length of their Tails increaſes very conſiderably in their nearer Approach to the Sun: But as ſoon as they begin to recede from the Sun, their Extent is vaſtly more augmented; becauſe then the projectile Force, and that of Repulſion, conſpire together, and act almoſt in the ſame Direction: So that the Tail moves with the whole projectile Force of the Comet, increaſed by its own repulſive Force, and muſt conſequently move with much greater Velocity than the Comet; and would leave it far behind, was it not for the Comet's Attraction, which all the while acts upon it with a Force decreaſing, as the Squares of the Diſtances increaſe. The Direction of the Tails will neither conſpire with that of the repulſive Force nor that of the projectile, but each of their component Corpuſcles will move in the Diagonal of both Forces. Thoſe Corpuſcles which are neareſt the Body of the Comet will have moſt of the projectile Force, and move moſt in its Direction: Therefore thoſe which are fartheſt from it will be leaſt influenced by the projectile Force, and move moſt in the Direction of the other, eſpecially if the repellent Corpuſcles decreaſe in Size at greater Heights of the Atmoſphere; becauſe then their repulſive Force will be proportionably greater. *Prop.* 41. Now if the component Corpuſcles of the Tails move in different Directions at different Heights from the Comet, the Tails themſelves will be in different Directions at different Heights, and conſequently be curved. That Part of them which is neareſt the Comet, will be moſt in the Direction of the Comet's Motion; and that Part which is fartheſt diſtant, will be moſt in the Direction of the repulſive Force.

## PROP. LXVI.

If a Number of equal and perfectly elaſtic Bodies are ranged in a direct Line, ſo as to be contiguous to each other, and a Motion be communicated to the firſt in the Direction of that Line, the laſt Body in the Series will receive the Momentum of the firſt, by the Intervention of the intermediate Bodies, and no Motion will be communicated to the intermediate Series, beſides a Tremor continued from one to the other: After which they will be all at reſt, except the laſt.

This is a direct Conſequence of the known Laws of elaſtic Bodies; for all the Bodies being equal and perfectly elaſtic, the whole Momentum of the firſt Body will be received by the ſecond, and the firſt will remain at reſt; the ſecond will communicate its whole Momentum to the third, and then be at reſt alſo; and ſo on till you come to the laſt.

## COROL.

This Law will perfectly take place in a continued Series of elaſtic Particles, ſuch as compoſe our repellent Fluid; becauſe they are of all Bodies the moſt perfectly elaſtic.

## PROP. LXVII.

By how much theſe elaſtic Bodies are ſmaller, and more compreſſed together, by ſo much the leſs will they be moved from their Places, in communicating their Motion from one to the other, *cæteris paribus.*

The greater the Compreſſion is already, the greater will be the Reſiſtance to a further Compreſſion; and the greater that Reſiſtance, the leſs Space will be moved through by the Body in Motion, before its Motion is deſtroyed: Likewiſe the leſs the Momentum of the moving Body, the leſs Space it will move through before that Momentum is deſtroyed. But the leſs the Body is, the leſs will be its Momentum, *cæteris paribus.*

## COROL.

Wherefore when elaſtic Bodies are indefinitely ſmall, and the Degree of Compreſſion indefinitely great, their Removal from their Places will be indefinitely ſmall, in communicating any Degree of Motion whoſe Velocity is finite.

## PROP. LXVIII.

If a ſtrait Line be ſuppoſed to paſs in any Direction whatſoever through a Part of Space occupied by the repellent Fluid, all the repellent Particles that are in the Direction of that Line, may be conſidered as a Series of elaſtic Bodies: And if the firſt Particle ſtrikes the ſecond with a certain Degree of Velocity, the ſame Velocity will be communicated to the laſt; and if all the intermediate Particles are contiguous, their Motion from their Places will be indefinitely little.

If all the intermediate Particles are not contiguous, yet the Motion will be continued from one to the other; only with this Difference, that where the Series is any where interrupted, the repellent Particles will have to move further from their Places: But ſince it appears, from *Prop.* 31. that the Number of repellent Particles in any aſſignable Part of Space, how ſmall ſoever, may be indefinitely great, no Series of them in any Direction can be a great Way interrupted; eſpecially when we conſider, that their equally repellent Forces will naturally range them in a regular Manner: So that in moſt Caſes, the Particles of one Series will be oppoſed to the intermediate Spaces betwixt the Particles of the next, in the Manner of a *Quincunx*. When all the Particles of a Series are contiguous, the Removal of the intermediate ones from their Places will be indefinitely ſmall, by the laſt *Corol.* For the Particles themſelves are indefinitely ſmall, *Prop.* 24. & *Corol.* and their Degree of Compreſſion may be alſo indefinite. The Degree of Compreſſion will be equal to the expanſive Force of the repellent Fluid, which will be in Proportion to the Number of repellent Particles contained in any given Space; but the Number of repellent Particles contained in any given Space, how ſmall ſoever, may be indefinite. *Prop.* 41. *Corol.* 1, 2.

PROP.

## PROP. LXIX.

All the *Phænomena* of Light and Colours will be the ſame, whether we ſuppoſe the Propagation of Light performed by a progreſſive Motion of its Particles, or by the Vibrations of our repellent Fluid.

It makes no Difference, in reſpect to the Action of a Body impinging upon another, whether the impinging Body has moved already through a great Space, or is only juſt put in Motion, provided the Velocity and Direction be exactly the ſame in both Caſes. Therefore a Particle of Light will ſtrike upon the *Retina* of the Eye with the very ſame Effect, when it receives its Motion from the next contiguous Particle, as when it has moved all the Way from the Sun, with the ſame Direction and Velocity. And it is much eaſier to comprehend how a Tremor may be propagated from one End of a Series of elaſtic Bodies to the other, in the ſame Time that Light takes up in coming from the Sun to us, than to conceive how a Particle of Light can continue its Motion and Direction unaltered, through ſo vaſt a Space, and with ſo great a Velocity; whilſt innumerable other Particles are every where moving in different and often contrary Directions. Is it poſſible that it can move ſo far, and not frequently impinge upon other Particles, when every minute Part of Space muſt contain Thouſands of them? What Confuſion muſt neceſſarily ariſe in the Direction of its Motion from ſuch a Variety of Percuſſions! But ſuppoſing the Motion propagated through our repellent Fluid, theſe Difficulties immediately vaniſh. In that Caſe, the Motion may be conveyed in all Directions at once, without Danger of Confuſion; becauſe by the laſt Propoſition the Motion of the intermediate Particles from their Places will be inconſiderable; and from the Nature of Percuſſion, amongſt equal elaſtic Bodies, one Particle is no ſooner removed from its Place, but the Particle which removed it, takes Poſſeſſion of the ſame, and remains there at reſt. The moſt obvious Objection to this Doctrine is, that in a repellent Fluid a Particle in Motion will not only act upon the next that lays exactly in the Direction of that Motion, but alſo upon all thoſe that are placed but a very little Way out of that Direction; and by this Means ſeveral other Vibrations will commence, which will be communicated in ſuch Directions as correſpond with the Degrees of Obliquity with which the Particles act: Whereby Light will not only be propagated from one Body to another, in right Lines, but will at the ſame Time be communicated ſide-ways, in almoſt all Directions. And this will not only create Confuſion in regard to Viſion, but alſo make it impoſſible that there ſhould be any Darkneſs in the Night. To this I anſwer, that even granting a Particle of the repellent Fluid will act upon ſuch Particles as lay but a little Way out of the Direction of its own Motion, yet it will not act on them with the ſame Force as it does on thoſe directly in its Way; therefore theſe lateral Vibrations will be much weaker than the direct ones, which give us the Senſation of Light: However, though theſe Vibrations may be too weak for our Organs, yet they may be well enough ſuited to the delicate Structure of the Eyes of many Inſects and Animalcula, and even of ſome larger Animals; for doubtleſs what is Darkneſs to us, is not ſo to many of them. The ſame Thing happens in regard to Sounds: For if all the Vibrations of the Air were capable of affecting our Organs of Hearing, there could be no ſuch Thing as Stillneſs or Silence; becauſe the Particles of Air muſt be put in continual Vibrations in all Directions, by every little Percuſſion that happens among Bodies. All Nature is perpetually in motion; and every Motion, in ſuch an elaſtic Fluid as the Air, muſt be attended with a greater or leſs Vibration of that Fluid. As to the Objections that may be drawn from the Analogy betwixt the Waves in Water, and the Undulations of an elaſtic Fluid, they will be anſwered all at once, by denying the Exiſtence of theſe Undulations; at leaſt with regard to the Propagation of Sound or Light. I will not ſay, that the Air is never made to undulate: The Winds themſelves have often a Wave like Motion; but this is not Sound: A large Body in Motion through the Air may make

Undulations in it. The Oſcillations of a Pendulum, or the String of an Inſtrument, may do the ſame. But none of theſe are the immediate Cauſe of Sound. The moving Body, Pendulum and String are all ſilent. Only it generally happens in the laſt Caſe, that whilſt the String performs its Oſcillations, its component Corpuſcles, being elaſtic, are put into a tremulous Motion, which Motion they communicate to the circumambient Air. Touch the String with a ſoft unelaſtic Body, and the tremulous Motion of the Parts ceaſes. But the String continues to oſcillate for a long Time after with as much Silence as a Pendulum.

From the whole of what has been ſaid, I think it is ſufficiently evident, that the Effect of Light will in all Caſes be the ſame, when its Motion is propagated through a repellent Fluid, as when it is progreſſive, in the Manner that Sir *Iſaac Newton* has ſuppoſed. So that the whole Theory of Opticks, demonſtrated by that excellent Philoſopher, continues the ſame as before. Only one Thing, that is of any Conſequence, remains to be reconciled, I mean his Doctrine of Colours. He ſhews the Diverſity of Colours to be owing to the different Momenta of the Particles of Light, and ſuppoſes their Momenta to differ on account of their different Magnitudes. I have ſuppoſed all the Particles of Light to be of the ſame Size. This was done for the ſake of Simplicity, which muſt always take place, as far as the Nature of Things will admit. And the Momenta of the Particles of Light will differ, though their Sizes are the ſame, if Light be propagated by Vibrations. For in the ſame Manner as the Tones in Muſick make a Difference in Sound, according as thoſe Vibrations are quicker or ſlower; ſo the Momenta of the Particles of Light will differ, according as they vibrate with more or leſs Force. A great many will be ready to object; that if the Particles of Light are equal, and yet their Momenta different, they muſt move with different Velocities: And conſequently that the red Rays will come from Jupiter to us, in leſs Time then the blue. I grant the Premiſſes, but deny the Conſequence: For Sound moves with equal Velocities, let the Tone be what it will. What I advance may at firſt Sight appear a very great Paradox. But it ſeems evident to me, that in two different Series of equal and elaſtic Bodies, thoſe of one Series may move with greater Velocity than thoſe of another, and yet the Propagation of Motion from one to the other be performed in equal Times. Inſtead of a Mathematical Figure, I'll explain the Caſe by a familiar Inſtance. Suppoſe two Men were to ſtrive which could give the quickeſt Intelligence at an hundred Miles Diſtance, and the Method they both pitched upon was to place a Man and Horſe at the Diſtance of every ten Miles; and give orders that the firſt Man ſhould make what ſpeed he could towards the ſecond, till he came to a certain diſtance, and that then he ſhould fire a Gun; upon hearing of which, the ſecond ſhould ſtart, and at a like Diſtance alſo fire his Gun; and then the third ſtart, and ſo on to the laſt: Let one Man's Horſes be all able to go nine Miles whilſt thoſe of the other could only go eight: And let the Riders of the firſt fire their Guns when they had rode nine Miles. And thoſe of the ſecond at eight Miles from their Place of Starting, it is plain that the Intelligence would arrive at the ſame Time in both Caſes, becauſe the Riders of both would fire their Pieces at the ſame Time. The Caſe is exactly ſimilar in two Series of repellent Particles placed at equal Diſtances. If thoſe of one Series move all ſwifter than thoſe in the other, yet nothing can be gained thereby if each Particle moves proportionably farther before the next ſtarts, which muſt neceſſarily be the Caſe; for it will move on till its Motion is deſtroyed by the Re-action of the next: And the greater its Momentum, the farther it muſt move before that Momentum is deſtroyed.

From all theſe Conſiderations we may ſafely conclude, that all the *Phænomena* of Light and Colours will be the ſame, when produced by Vibrations in a repellent Fluid, as when produced by a progreſſive Motion of the Particles. When we come to apply theſe Principles to Opticks in particular, a great many beautiful Truths will ariſe from them, and add not a little to the Improvement of that Science.

## PROP. LXX.

If the Atmoſpheres of the Sun and Stars are proportionable to their Magnitudes, and conſiſt of repellent Corpuſcles of different Sizes, decreaſing gradually from the largeſt that will repel, to the ſmalleſt that can be ſuppoſed, all the Vibrations that happen in the lower Parts of their Atmoſpheres, and are propagated upwards, will be communicated to the repellent Fluid above, and cauſe Light.

If the repellent Corpuſcles compoſing the Sun's Atmoſphere are of unequal Sizes, they will naturally diſpoſe themſelves at different Heights, according to their different ſpecific Gravities: So that from the Bottom to the Top of the Atmoſphere, they will make a decreaſing Series of Bodies; and the ſmalleſt of all at the Top may conſiſt of only two or three attracting Particles, ſurrounded with repellent ones. The vaſt Weight of the Sun's Atmoſphere muſt make the Denſity of the Air ſo great near the Sun's Surface, that what would create a Sound ſcarce audible with us, would there produce a very loud Noiſe. The Velocity of Sounds in ſo denſe an Air muſt likewiſe be very great. Thoſe Vibrations that are propagated upwards will paſs through a decreaſing Series of perfectly elaſtic Bodies; and therefore according to what has been demonſtrated by that great Mathematician Mr. *Huygens*, the Velocity of the laſt Body in the Series will be prodigious; for the Velocity of the firſt Body was very great. What then muſt it be, when increaſed through ſo long a Series! Can there be any Doubt of its being equal to that of Light? And if ſo, will not the laſt and leaſt Corpuſcles of the Sun's Atmoſphere be capable of producing the ſame Vibrations in the repellent Fluid, every where ſurrounding it, and ſtrongly condenſed upon it? And will not thoſe Vibrations be continued in right Lines from the Sun, through the whole Immenſity of Space occupied by the repellent Fluid? Hence we ſee why the Sun and Fixed Stars are the grand Fountains of Light and Heat; and why they ſhine with Light of their own, whilſt the reſt of the heavenly Bodies reflect it only from them. Hence the

Reaſon why their Light is of no Service to us in diſcovering any thing upon their Surfaces; the Proportion of what is reflected from thence being very little, in Compariſon to what is generated by the Vibrations of their Atmoſpheres. Their Globes are no longer frightful Gulphs of Fire, but inhabitable Worlds: Thoſe Philoſophers who thought them too hot for the Habitation of Salamanders, and thoſe ſublimer Genii, who thought them to be Hells, will now perhaps be in Pain, leſt the Inhabitants ſhould freeze with Cold. But let us be under no Concern; all-wiſe Providence has taken care of all Things for the Good of his Creatures.

## PROP. LXXI.

If Light in a ſufficient Quantity enters the Pores of a ſolid or fluid Body, the Quantity of repellent Matter will be thereby increaſed, the Body expanded, and the common Effects of Heat produced.

Light is nothing but the repellent Fluid put into very violent Vibrations, *Prop.* 69. When theſe Vibrations are continued in a right Line, till they arrive near the Surface of a Body, they will begin to be acted upon by the repellent and true Atmoſphere ſurrounding that Surface, and either be repelled thereby, or have Force ſufficient to penetrate within thoſe Atmoſpheres: If the latter, the ſame Vibrations will be continued through the repellent Atmoſphere, only the Direction will be changed towards the Perpendicular; becauſe the repellent Particles will be acted upon by two Forces, in different Directions; (except when the Light falls perpendicular to the Surface) for within the Atmoſpheres of Bodies the repellent Matter is attracted towards the Surface, *Prop.* 31. Light will therefore move within the Atmoſphere of Bodies, in the Diagonal of the projectile and attracting Force; and by the Continuation and Increaſe of that attracting Force, will be made to deſcribe a Curve, and come nearer the Direction of a Line drawn perpendicular to the Surface; where, when it arrives, it will either fall upon a Pore or ſolid Part: If the former, it will enter among the component Corpuſcles of the Body, and increaſe the repulſive Force betwixt thoſe Corpuſcles, which muſt make them recede farther from each other, and conſequently the Body will be dilated. The greater the Quantity of Light that thus enters amongſt the component Corpuſcles of Bodies, the greater will be their Expanſion: Heat therefore will be moſt produced, where the greateſt Number of repellent Particles are in a vibratory Motion without the Body. Nor is it neceſſary that thoſe Vibrations ſhould be always ſo violent as to excite in us the Senſation of Light. A very ſmall Vibration will be ſufficient, when the Direction of it is perpendicular to the Surface. Hence we ſee the Difference betwixt Light and Heat: The firſt may be produced by a few vibrating Rays, provided thoſe Vibrations are briſk enough; the latter may be produced by much weaker Vibrations, provided the Rays are ſufficiently numerous.

## PROP. LXXII.

The denſer Bodies are, the longer they will be in receiving Heat, but will retain it more ſtrongly when received.

The Truth of this Propoſition is founded upon Experience, but the Reaſons are not ſo obvious. If Heat was excited by the repellent Fluid's entering the Pores of a Body in a Stream, it would flow out as faſt as it came in, and little or no Expanſion would be produced: But ſince it is propagated by Vibrations, thoſe Vibrations will be continued within the Pores, either in an uniform or irregular Direction, according to the regular or irregular Diſpoſition of the Pores. The denſer the Bodies are, the greater will be the Denſity of their Atmoſpheres; and in Proportion to the Denſity of their Atmoſpheres, more of the Vibrations will be reflected back from the Surface; and conſequently fewer will enter. In like Manner, when the Vibrations which have entered arrive again at the outward Surface, and would make their Egreſs, they will be more or leſs reflected back into the Pores, in Proportion to the Denſity of repellent Matter on the Surface; therefore the Denſity of their Atmoſpheres will make the Ingreſs and Egreſs of the Vibrations equally difficult, and conſequently the denſer the Bodies are, the longer they will be in receiving Heat; but retain it ſo much the more ſtrongly when received.

### COROL.

The Denſities of Bodies and their Atmoſpheres will be exceeding great upon the Surfaces of the Sun and Stars, and larger Planets; and therefore, if they have a conſtant Supply of Heat, though it be in a leſs Quantity, yet their retaining it ſo much longer will make Amends for the Defect.

## PROP. LXXIII.

The Air and repellent Fluid will mutually ſupply the Place of each other in ballancing the Force of Attraction; and where the Air can have Acceſs, the other will give Place: But the Air being expelled, will be again reſtored.

The Air contains more repellent than attracting Matter, and muſt therefore increaſe the Force of Repulſion in all Bodies, to which it is any Way united: For which Reaſon, the more Air is united to Bodies, the leſs, *cæteris paribus*, will be the Quantity of the repellent Fluid condenſed upon their Surfaces, and in their Pores, becauſe leſs is wanted to ballance the Force of Attraction. Where the Air can have Acceſs, its Determination towards Bodies will be greater than that of the repellent Fluid, *Prop.* 54. but where it cannot, or is by any Cauſe removed, then the repellent Fluid will be condenſed in Proportion to the Defect of repellent Matter. *Prop.* 32.

### COROL. I.

The Air will endeavour to unite itſelf to all Bodies where it can have Acceſs, in Proportion to the Defect of repellent Matter in thoſe Bodies; and if the Pores are large enough, it will enter with conſiderable Force, and in Part expel the repellent Fluid. The *Niſus* of the Air to penetrate into the Pores of Bodies will be much increaſed by the Weight of the Atmoſphere. Very ſmall Pores will not eaſily admit the Air, becauſe the ſolid Parts ſurrounding the Entrance will be covered with Particles of Air, which will repel thoſe that endeavour to enter. For this Reaſon the Particles of many denſer Fluids will enter where the Air cannot, though they be really larger than the Particles of Air.

## COROL II.

By this Means the Air will be intimately incorporated with moſt Subſtances, and will become a component Part of even the moſt ſolid Bodies; and when ſolid Bodies are reduced to Powder, the Air having then free Acceſs to every minute Particle, unites itſelf thereto; and where the Particles are very ſmall, the Quantity of Air united to their Surfaces is ſufficient to make them light enough to float in the Atmoſphere. In like Manner when ſolid or fluid Bodies have their Parts ſo much expanded by Heat, that the Air is able to inſinuate itſelf amongſt them, they are ſoon carried up in Form of Fumes or Vapour. Fluids indeed of moſt Kinds do not ſo much want the Air's Aſſiſtance to make them volatile, becauſe a moderate Heat will expand them to ſuch a Degree, that their component Corpuſcles will be carried out of the Sphere of each other's Attraction, and then they will begin to repel each other: For as ſoon as two Corpuſcles have got ſo much repellent Matter round them, that their attracting and repelling Forces are *in equilibrio*, a ſmall Addition of Heat muſt increaſe their repulſive Force, and make them repel. Sir *Iſaac Newton* has obſerved, that where the Sphere of Attraction ends, that of Repulſion begins; and that Bodies which attract ſtrongeſt whilſt within the Sphere of each other's Attraction, will have the ſtrongeſt Repulſion when out of it. He diſcovered this Law from Facts and Obſervation: But it is not difficult to deduce it from the Principles already explained. The ſtronger the Attraction is betwixt the Parts of a Body united, the more repellent Matter will be collected round them when ſeparate.

## PROP. LXXIV.

The repellent Fluid contained in the Pores of Bodies, but not in Contact with their component Corpuſcles, will ſeldom exceed the Quantity which the Space occupied by the Pores ought to have upon an equal Diſtribution.

The Air, that is intimately incorporated with the component Parts of moſt Bodies, will be one Cauſe of diminiſhing the Quantities of the repellent Fluid within the Pores, *Prop.* 73. *Corol.* 2. and the Repulſion betwixt the Surfaces of the component Corpuſcles will be another very powerful one. For the component Corpuſcles being ſtrongly compreſſed together by the Force of Attraction, the repellent Matter united to their Surfaces will be condenſed by the ſame Force, and its repellent Force will be proportionable to that Condenſation. Therefore this Force will ſtrongly reſiſt the repellent Fluid that endeavours to enter the Pores. So that theſe two Cauſes conſpiring, will make the Quantities of the repellent Fluid contained in the Pores, very ſeldom exceed what the Pores ought to have upon an equal Diſtribution, independent of the ſolid Parts.

### COROL. I.

Therefore in moſt Bodies the repellent Matter contained in the Pores, but not united to the component Corpuſcles, cannot be conſidered as a Part of what belongs to the Body: Becauſe the Space occupied by the Pores ought to contain it independent of the ſolid Parts.

### COROL. II.

If a very denſe Body has nevertheleſs here and there very large Pores interſperſed, and thoſe Pores be either wholly, or in a great Meaſure devoid of Air; there may be contained in ſuch Pores more of the repellent Fluid than would belong to the Space occupied by them.

### PROP. LXXV.

If the Air is ſuddenly removed from the Surface of a ſolid Body, the repellent Fluid will as ſuddenly ruſh upon it to ſupply its Place.

This is evident from *Prop.* 73, for the repellent Fluid will be inſtantly reſtored to its Place, when the Air which had taken Poſſeſſion of it is removed, being always ready at hand.

## COROL. I.

The more ſudden the Removal of the Air, the more violently will the repellent Fluid ruſh in to ſupply its Place.

## COROL. II.

The repellent Fluid, in ruſhing upon the Surface of a ſolid Body, will partly enter its Pores and expand the Body, and partly be reflected.

For what falls upon the Pores will enter, and the ſolid Parts being covered with repellent Matter, will reflect what falls upon them. Hence we ſee the Reaſon why two ſolid Bodies, violently rubbed together, produce Heat, Light and Fire: For the Air, condenſed upon and united to their Surfaces, is alternately removed and reſtored; and conſequently the repellent Fluid is continually making freſh Impulſes upon theſe Surfaces; more and more continually enters the Pores of the Bodies, and expands them. The component Corpuſcles of each Body are put into a briſk oſcillatory Motion, and their Pores thereby alternately contracted and dilated; alternately drawing in and preſſing out the repellent Fluid: The Air all the while is put into ſtrong Vibrations, which create a harſh Sound, and by the Continuation and Violence of the Attrition, the Vibrations in the repellent Fluid become at length ſtrong enough to produce Light and Fire.

## COROL. III.

As long as the component Corpuſcles continue their Oſcillations, ſome Degree of Heat will continue, though the firſt productive Cauſe ceaſes to act; becauſe thoſe Oſcillations muſt alternately contract and dilate the Pores of the Body: By which Means the repellent Fluid will be alternately drawn in and preſſed out of the Pores.

## PROP. LXXVI.

If thoſe Subſtances, which contain many of the ſmalleſt attracting Corpuſcles united with neutral ones, have once a ſufficient Degree of Heat communicated to them to produce

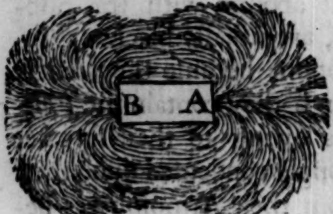
Flame, they will be able to continue or even increaſe that Heat, provided the Air have free Acceſs.

The Air will be repelled by the ſmalleſt attracting Corpuſcles, *Prop.* 47. §. 1. & 4. therefore the Air cannot ſupply the Place of their repellent Atmoſpheres by uniting itſelf to them. Whether they be ſurrounded with neutral Corpuſcles, or united to others more attracting than themſelves, their Separation will be effected by a leſs Degree of Heat than that of any other attracting Corpuſcles, becauſe they have the leaſt Spheres of Attraction; and upon their Separation the repellent Matter will throw itſelf round them in Form of Atmoſphere. So that they may be conſidered as the *primum Mobile* in agitating the repellent Fluid. Neutral Corpuſcles are not fit for this Purpoſe, becauſe they do not attract the repellent Fluid; and the larger attracting Corpuſcles require a conſiderable Degree of Heat to ſeparate them, and the Air readily unites itſelf to them when ſeparate. But the Preſence of the Air is abſolutely neceſſary for the Continuance of Fire and Flame; for by its Preſence it confines the more volatile and active Parts from flying away, before they are heated enough to ſeparate their ultimate component Corpuſcles; and by the Elaſticity of its Corpuſcles it reflects back upon the Body the Vibrations of the repellent Fluid, and alſo thoſe of the expanſive Vapour ariſing from the Body. Nor is it of leſs Service by its continual Succeſſion in carrying away with it the unelaſtic Fumes that are continually ſeparated from the burning Subſtance, and which would, if continued, more and more weaken the Vibrations of the repellent Particles, ſo neceſſary to the Continuance of Heat and Fire. What I mean by unelaſtic Fumes is nothing but the *Phlogiſton*, or ſmalleſt attracting Corpuſcles, which having performed their Office in making a Conflux of repellent Matter, and being ſurrounded with their repellent Atmoſpheres, are now no longer of uſe in promoting the Vibrations of the repellent Fluid, but rather deſtroy or weaken the Motion of every repellent Particle that impinges againſt them; for which Reaſon I call them unelaſtic. That theſe Corpuſcles will, in a great Meaſure, be unelaſtic in reſpect to the Particles of the repellent Fluid, I conclude from hence: Each Corpuſcle is ſurrounded with a little Atmoſphere of repellent Matter; wherefore a Vibration will not be reflected from that Atmoſphere, but be continued to the repellent Surface of the Corpuſcle before it will be reflected. In its Deſcent, the repellent Particles of the Atmoſphere will act contrary to its Motion, and retard it; for the Acceſſion of a new Particle in the Atmoſphere muſt make all thoſe that were there before recede farther from the Corpuſcle; and ſince Action and Re-action are equal, the acceding Particle will be retarded by the ſame Force with which the others are made to recede by it: Wherefore the Vibrations will be weaker when they arrive at the Surface of the Corpuſcle, than when they firſt entered its repellent Atmoſphere. They will alſo be retarded after their Reflection, in coming out of the ſaid Atmoſphere; becauſe the Attraction of the Corpuſcle acts contrary to the Motion of each vibrating Particle, as far as the repellent Atmoſphere reaches. It is for this Reaſon that the Corpuſcles of the *Phlogiſton* are of all others the leaſt capable of reflecting Light; whence Bodies that abound with this Subſtance pure and ſuperficially united, are uſually black. Metals are in ſome Reſpects an Exception, becauſe they reflect more Light than other Bodies, though they contain the *Phlogiſton* in great Plenty. But this is owing to their greater Denſity; whereby the Air is ſo ſtrongly condenſed upon their Surfaces, that Light is reflected from their Atmoſpheres before it arrives at their Surfaces. But when the Parts of Metals are very minutely divided by Attrition, or any other Means, ſo that they become too ſmall to condenſe a ſufficient Quantity of Air, they then appear black. All the Light that paſſes the outward Atmoſphere of Metals, is little or not at all reflected, or tranſmitted, being immediately ſuffocated in the Pores by the *Phlogiſton*. Hence we may derive the Cauſe of their Opacity.

*Quære*, Is not this the Cauſe why all Bodies, which contain the *Phlogiſton*, attract Light ſtronger than others, as Sir *Iſaac Newton* has obſerved?

## PROP. LXXVII.

If the Parts of a very denſe Body be ſo conſtituted, that more repellent Matter may be contained in its Pores than what would belong to the Space occupied by them, and that repellent Matter by any Cauſe whatſoever be put in Motion, ſo as to move in a continued Stream in one Direction within the Pores, thoſe Pores from whence the Stream moves will be ſupplied by a Conflux of the ſame Matter from without; and the Stream of repellent Matter, coming out of the Body at the oppoſite Side, will be carried round to the Side where it firſt began, to ſupply the Place of what enters the Body there: By which Means, a Circulation of the repellent Fluid may be continued through the Body, going in at one Side and coming out at the oppoſite, and then moving back without to the Place where it firſt entered, to be again admitted: And this Motion will be perpetual.



Suppoſe A B to repreſent a Body, and that the repellent Matter contained in its Pores be put in Motion, ſo as to move from B to A: As ſoon as that Motion begins, the Pores at B will be emptied of the repellent Matter which they contained, by its Removal towards A: And ſince the external repellent Fluid expands itſelf on all Sides, it muſt enter to ſupply its Place: But at the ſame Time that the Motion begins, the repellent Matter will flow out at A into a Part of Space, which has already its due Proportion: It will therefore be accumulated, and be ready to diffuſe itſelf every Way; and if there be leſs Reſiſtance one Way than another, it will be determined towards that Quarter: It will therefore be determined towards B, becauſe the repellent Matter that has entered there, has leſſened the Quantity in that Part. Now it is evident, that this Circulation will continue for ever, unleſs interrupted by ſome external Cauſe: For the repellent Fluid will enter at B, with a Velocity equal to that with which it moves from B to A: It will come out at A with the ſame Velocity; and it will be carried back from A to B with the ſame Velocity as that with which it enters at B; for the Flux from A to B muſt be proportionable to the Want of it at B, which will be in Proportion to the Velocity with which it enters at B: Therefore if the Velocity continues always the ſame, the Motion will be perpetual.

*Note*, The Reaſon why the Stream muſt be always ſupplied at the Place where it firſt entered, will appear afterwards in *Prop.* 85.

### COROL. I.

This Circulation of [illegible] repellent Fluid perfectly agrees with that of the magnetic Virtue of a Loadſtone, if we ſuppoſe B the North Pole, and A the South: For the Manner in which Steel-Filings diſpoſe themſelves round a Loadſtone expreſſes very exactly the Direction of the magnetic Virtue, and very well correſponds with the Circulation here deſcribed. So that if all the *Phænomena* of the Loadſtone can be explained by ſuch a Circulation of the repellent Fluid, and a Reaſon can be given why this Circulation produces the Effects of Magnetiſm in no Bodies but ſuch as contain Iron, I think the whole Myſtery of Magnetiſm will be accounted for.

### DEF.

The Quantity of repellent Matter that circulates through a Loadſtone, or other magnetical Body, I call the Quantity of abſolute Magnetiſm.

### COROL. II.

This Motion of the repellent Fluid has no Connection with that vibratory Motion which is the Cauſe of Light, and can no more produce Light than a gentle Breeze can

produce

produce a Sound. The Wind indeed produces Sound in a Storm, by ſtriking violently upon Bodies oppoſed to it; but then, by the ſame Analogy, we muſt not expect Light from a Loadſtone, till we can produce a Storm of Magnetiſm.

## PROP. LXXVIII.

If two Loadſtones, that have the repellent Fluid circulating as explained above, be ſituated ſo, that the South Pole of one be applied to the North of the other, they will mutually attract each other.

I call that Part the North Pole where the repellent Fluid enters, and that the South, where it comes out: Therefore when the South of one is applied to the North of the other, the Stream of repellent Matter will be carried from one to the other; ſo that it will not circulate back again, till it has paſſed through both Loadſtones. Now it was ſuppoſed in the laſt Propoſition, that the circulating Fluid was more than what belonged to the Space occupied by the Pores of the Body, and conſequently ſome Part of it muſt be what belongs to the Space occupied by the ſolid Parts; that is, it muſt be a Part of the repellent Matter belonging to the Body itſelf, and ſhould ſerve to counter-act the attracting Force of the Body: So that when the Loadſtones are thus applied to each other, a Part of the repellent Matter, which ſhould ballance their Force of Attraction, is moving directly through them both; and conſequently can have no Effect in hindering the two Bodies from being attracted towards each other: For, whether they be placed at a greater or leſs Diſtance, the repellent Matter that paſſes out of one into the other will all the while have the ſame relative Diſtance in regard to its own Parts; and therefore can no more be inſtrumental in making the two Bodies recede from each other, than a String or Wire paſſing through them. Hence we may conclude, that the repellent Force betwixt the two Loadſtones will be diminiſhed in Proportion to the Quantity of repellent Matter paſſing from one to the other; and that the attracting Principle will prevail in the ſame Proportion. *Prop.* 48. *Corol.* 4.

## DEF.

The Quantity of repellent Matter that paſſes from one magnetical Body to another, I call their Quantity of relative Magnetiſm.

## COROL. I.

Therefore the Force of Attraction betwixt two Loadſtones will be, *cæteris paribus*, in Proportion to their Quantity of relative Magnetiſm.

## COROL. II.

Two Loadſtones of equal Magnitudes will attract at different Diſtances with a Force that will be in a Ratio compounded of the direct Ratio of their Quantities of relative Magnetiſm, and of the reciprocal Ratio of their Diſtances; becauſe the Attraction will increaſe as the Diſtances decreaſe, by the general Law of Attraction.

## COROL. III.

Therefore if the Quantity of relative Magnetiſm be the ſame in two Loadſtones at different Diſtances, the Force of Attraction at thoſe Diſtances will be ſimply in the reciprocal Ratio of their Diſtances; but if that Quantity increaſe as the Diſtances decreaſe, then the Force will be in the reciprocal Ratio of the Squares of the Diſtances: If the Quantity increaſes as the Squares of the Diſtances decreaſe, then the Forces will be inverſely as the Cubes; and ſo on. Now on the other hand, if in any Caſe the Quantity ſhould increaſe in ſome direct Ratio of the Diſtances, then the Force may happen to be in a leſs Ratio than that of the Diſtances reciprocally; or even increaſe as the Diſtances directly.

## COROL. IV.

From the laſt it is evident, that if in different Pairs of Loadſtones the Quantities of relative Magnetiſm may be different at different Diſtances, and that in very different Ratio's of thoſe Diſtances, then there can be no certain Law of Attraction peculiar to Magnetiſm; and that the univerſal

Law of Attraction is here only variouſly modified by the Irregularity of the repellent Principle.

### COROL. V.

Since almoſt all Loadſtones are more or leſs heterogeneous, and ſome of them very much ſo, the Force of magnetic Attraction will not act always in Lines drawn from the Center of the Stone; and the Diſtances muſt not be computed from thence, but from the Center of thoſe Parts that are magnetical.

### COROL. VI.

The ſmaller Loadſtones are, the greater will be their Force, *cæteris paribus*, in Proportion to their Magnitudes. This will follow from the general Law of Attraction. *Prop.* 11. *& Corol.*

### PROP. LXXIX.

The Quantities of relative Magnetiſm may be very different at different Diſtances, and that in different Ratio's of the Diſtances.

§. 1. The Quantities of relative Magnetiſm are as the Quantities of repellent Matter, that paſs from one Loadſtone to another, by the *Def.* Therefore we are to prove, that at different Diſtances the Quantities of repellent Matter that will paſs from one Loadſtone to another may be different, and that in different Ratio's of the Diſtances.

§. 2. If a Loadſtone be by itſelf, the Stream of repellent Matter, that comes out at the South Pole, will move round and enter again at the North. *Prop.* 77. The Direction of its Motion in paſſing through the Stone is in the Direction of the Axis of the Stone, which may be called the Direction of its projectile Motion: As ſoon as it comes out of the South Pole, it diſperſes on all Sides; and in ſo doing is acted upon by a new Force in a different Direction: Therefore, by the known Laws of Motion, it will move in the Diagonal of the two Forces; and, by the continued Action of the latter, will be made to move in curve Lines, more and more diverging from the Direction of the Axis:

At the ſame Time it begins to be impelled by a third Force, acting in a Direction towards the North Pole: By this it will be made to diverge from the Axis much faſter; and thoſe Particles which come out of the Polar Surface at the greateſt Diſtance from the Axis, will be moſt acted upon by this laſt Force; and conſequently be made to diverge faſter, be ſooner made to move in a Direction contrary to the projectile Force, and be carried back to the North Pole. It is for this Reaſon that the magnetic Virtue that comes out at the Edges of the Polar Surface, is immediately acted upon by the oppoſite Pole, and carried back in almoſt right Lines juſt above the intermediate Surface: But this is moſt remarkable when the Axis of the Stone is very ſhort; becauſe the two Poles being in that Caſe very near, the Action of the North upon the repellent Matter coming out of the South, is proportionably ſtronger: The repellent Matter which comes out a little Way within the Edges of the Polar Surface, will not be drawn back to the oppoſite Pole with ſo much Force; and therefore will move in a larger Curve, that will be exterior to the other. In like Manner, in Proportion as the magnetic Virtue comes out at a leſs Diſtance from the Axis, it will be carried back in curve Lines, that will be larger and larger, and farther diſtant from the Stone. At or very near the Axis of a large Stone the magnetic Virtue diverges ſo little, that it appears to move for a great Way in the Direction of the Axis. If we lay a Piece of Paper upon a Loadſtone, whoſe Axis is parallel with the Horizon, and ſprinkle it over with Steel Filings, they will readily diſpoſe themſelves in the Direction of the magnetic Virtue; and expreſs the curve Lines in which it moves from one Pole to the other: And I think any one acquainted with the Laws of Motion will eaſily comprehend, that the ſeveral Forces, acting as above deſcribed, muſt neceſſarily make the repellent Matter move, in the ſame Manner as the magnetic Virtue appears to do; and the Whole of my Reaſoning will be too plain to require any further Illuſtration. One Thing will be obſervable in moſt Loadſtones, which is, that the magnetic Virtue generally comes out of the Sides, as well as at the Polar Surfaces; and that what comes out of the Sides of one Pole, enters in at the Sides of the other, at the ſame Diſtance from the Middle betwixt the Poles.

§. 3. After we underſtand the Manner how the repellent Matter moves, when a Loadſtone is alone, it will not be difficult to determine what will happen when the South Pole of one is brought near to the North of another: But ſince the moſt powerful Conviction, in regard to Facts, is from what we ſee with our Eyes, let us examine the Matter by the ſame Experiment with a Paper and Filings. Let two Loadſtones be laid at ſome Diſtance from each other; let the South of one be oppoſed to the North of the other; lay over them a Piece of Paper, and ſprinkle it with Filings; and ſtrike the Table to make them all range themſelves in the Direction of the magnetic Virtue. Now let us reaſon on what appears: The Filings which lay directly betwixt the two Polar Surfaces, near their common Axis, are diſpoſed in right Lines, running from the South Pole of one to the North of the other; from whence I conclude, that about the Axis the magnetic Stream runs directly out of the South of one into the North of the other. At different Diſtances from the Axis, the Filings deſcribe regular curve Lines, which run from one Pole to the other, and diverge from each other in moving from the South Pole, till they come half Way; and then converge more and more through all the other Half of the intermediate Space, till they arrive at the North. From hence I conclude, that the repellent Matter, which comes diverging from the South Pole of the one, is made to converge again by the Action of the North Pole of the other, and is drawn into it. At the ſame Time, if we obſerve the Diſpoſition of the Filings, which lay on the Sides of the two Loadſtones, we may obſerve that thoſe which lay near the two Poles form Arches of Circles, which reach from one Loadſtone to the other; but thoſe which lay farther from the oppoſed Poles, and nearer their oppoſite Poles, form Arches of Circles which are bent towards thoſe oppoſite Poles. From whence I conclude, that all the repellent Matter which comes out of one Loadſtone is not carried into the other, but that ſome of it, which is fartheſt out of the Sphere of Action of the other, is carried back in curve Lines towards the contrary Pole of the ſame Loadſtone; as it would have been, in caſe the other was not there. Theſe Things being obſerved, if you bring the two Poles nearer than before, and ſprinkle the Filings a-freſh, you will ſee the Arrangement of them nearly ſimilar to the former; but with this Difference, that there will be fewer Arches paſſing from one Pole to the other of the ſame Loadſtone, and more of them paſſing from one Loadſtone to the other: Alſo the internal Arches that are formed near the common Axis of the two Loadſtones, and reach from one Polar Surface to the other, will now approach nearer to ſtrait Lines. From whence it may be concluded, that the nearer the two Loadſtones are brought together, the more repellent Matter may paſs from one to the other, and leſs be carried back to the contrary Poles; and therefore the relative Quantity of Magnetiſm may be different at different Diſtances. The Alteration of the curved Lines betwixt the two Polar Surfaces ſhews, that as the Poles are brought nearer, the repellent Matter runs more directly out of one into the other. If the two Loadſtones are brought ſo near as to be almoſt in Contact, the Diſpoſition of the Filings ſhew, that all the Virtue of one enters into the other; unleſs where the Loadſtones are long, and have Part of their Virtue coming out of their Sides. It may not be amiſs to obſerve, that the Motion of the magnetic Virtue is more regular, when we make uſe of Steel rendered magnetical, inſtead of real Loadſtones; becauſe the latter are ſeldom uniform in the Diſtribution of their Parts.

§. 4. But though it appears from what has been ſaid, that the Quantity of relative Magnetiſm may be very different at different Diſtances, and that it can never be the ſame at all Diſtances; yet we muſt not infer from thence, that it always changes, upon every Change of Diſtance: For if two equal Loadſtones that are both very long, and have all their Virtue coming out and going in at their Polar Surfaces, have their two friendly Poles brought near each other, all the magnetic Stream of the one will be carried into the North of the other: And this will happen at a certain Diſtance; betwixt which and the Point of Contact an infinite Number of leſs Diſtances may be taken, in all which the Quantity of relative Magnetiſm muſt be the ſame; becauſe there is no Doubt, but that if the whole Stream paſſes from one to the other at a greater diſtance, it will alſo do it at a leſs. Therefore at all Diſtances where the whole Stream of repellent Matter paſſes from one to the other, the Quantity of relative Magnetiſm will be the ſame, and the Force of Attraction in the reciprocal Ratio of thoſe Diſtances, *Corol.* 3. The Force will continue in this Ratio till they are ſeparated to a certain Diſtance, at which the Stream of repellent Matter ceaſes to be all carried on from one loadſtone to the other, Part of it being carried back to the oppoſite Poles, and then the Force will diminiſh in an higher Ratio.

§. 5. If a ſmall Loadſtone be applied to the Axis of a very large one, and the Quantity of abſolute Magnetiſm in the ſmall one be greater than that of the large one, in Proportion to its Size; the Force of Attraction will be in a leſs Ratio than that of the Diſtances reciprocally, till you come to a certain Diſtance, and then it will begin to be reciprocally as the Diſtances; but at Diſtances ſtill greater, it will decreaſe in Ratio's ſtill higher. Firſt, Let us ſuppoſe the North Pole of the ſmall one in Contact with the South of the large one, in a Part about the Axis; then becauſe the large one has a leſs Quantity of Magnetiſm in Proportion to its Size than the ſmall one, the Stream coming out of the Part where the ſmall one is applied, will not be ſufficient to ſupply it with ſo denſe a Stream as its own, the ſmall one muſt therefore be, in Part, ſupplied by a lateral Conflux of repellent Matter brought round from its oppoſite Pole, which moving in a contrary Direction to the Stream coming from the great one, will produce a repulſive Force that will act contrary to that of the magnetic Attraction, and will be ſtronger in Proportion to the Nearneſs of the Loadſtones; becauſe the Stream coming from the larger, by diverging, becomes rarer at greater Diſtances; and if we ſuppoſe that at greater Diſtances more of it ſhould be made to converge towards the ſmall one to ſupply its Stream, it will amount to the ſame thing; for the more repellent Matter is ſupplied to the ſmall one out of the Stream of the large one, the leſs will be brought back from the oppoſite Pole of the ſmall one; and conſequently the Repulſion will be diminiſhed on that Account, and the Quantity of relative Magnetiſm rather increaſed: Therefore ſince there will be a repulſive Force decreaſing at greater Diſtances, and counter-acting the Force of Attraction, that Force will not decreaſe ſo faſt as in the reciprocal Ratio of the Diſtances; unleſs the Diſtance be ſo large, that the Quantity of repellent Matter paſſing from the greater to the ſmaller be very much decreaſed; in which Caſe the Quantity of relative Magnetiſm being much leſs than at nearer Diſtances, and the Repulſion too ſmall to be taken into Conſideration, the Force may begin to decreaſe in the reciprocal Ratio of the Diſtances, or even in an higher Ratio.

§. 6. This Repulſion will take place, not only where the Loadſtones are of different Magnitudes, but where the Magnitudes are the ſame, provided the Quantities of abſolute Magnetiſm are different; for if one Loadſtone has not a Stream ſufficient to ſupply the other, the other will be ſupplied by the Return of its own Stream; which moving contrary to that of the firſt, muſt produce a Repulſion. The Caſe will be much the ſame, if we ſuppoſe the South Pole of the ſtronger oppoſed to the North of the weaker; for then all the Stream of the ſtronger will not be able to enter the North of the weaker, but be reflected back, and thereby produce a repulſive Force, acting contrary to that of Attraction: The nearer they approach, the more will the repellent Matter be accumulated betwixt them, and the Repulſion the more increaſed: But probably the Repulſion will not take place at ſo great a Diſtance, as in the laſt Caſe; which may make ſome Difference in the Degree of Attraction at different Diſtances. I cannot but admire the Sagacity of the learned Profeſſor *Muſchenbroek*, who from a Number of accurate Experiments, tried with a View to diſcover the Law of magnetic Attraction, arrived at the Knowledge of this repulſive Force, and applied it, as I do, without knowing any thing of the Cauſe on which it depended.

§. 7. An infinite Variety of Irregularities will ariſe in the Attraction of Magnetiſm from the unequal Diſtribution of magnetical Particles in the Compoſition of moſt Loadſtones: In large ones particularly, this Inequality is very obſervable. If you dip one of the Poles of a large Loadſtone in Steel-Filings, and obſerve in what Manner they adhere to it, you ſeldom find them uniformly diſtributed, but diſpoſed in little Tufts here and there; in ſome Places very thickly placed, whilſt others are quite bare: Generally the Edges of the Polar Surfaces have the moſt, though not always, for ſometimes they have leſs than other Parts. Conſider what Effect this muſt have in regard to the Attraction at different Diſtances. For Inſtance, ſuppoſe two Loadſtones equal and ſimilar; and let the South of the one be in Contact with the North of the other: Let the Diſpoſition of their magnetical Parts be ſuch, that one Half of each Polar Surface ſhall have a great Share of Magnetiſm, and the other Halves little or none; and let the weak Half of one Surface be oppoſed to the ſtrong Half of the other; is there Reaſon to expect any great Degree of Attraction betwixt them whilſt thus in Contact? Remove them a little from each other, will the Attraction be leſſened by the Increaſe of Diſtance? It ſeems more probable that it would be increaſed; for when they are ſeparated, there is Room for the Stream, coming out of the ſtrong Side of the one, to be drawn acroſs the intermediate Space to the ſtrong Side of the other. I ſhould not therefore be ſurpriſed, if any one ſhould tell me they had two Loadſtones, both poſſeſſed of a large Quantity of Magnetiſm; and yet that when the South Pole of the one was in Contact with the North of the other, their Attraction was very little, but became ſtronger and ſtronger as they were removed from each other, till at a certain Diſtance their Force began to decreaſe again.

§. 8. The Dimenſions, Length and Shape of Loadſtones will alſo make a Difference in the Ratio of their Forces at different Diſtances: But it would be tireſome both to myſelf and the Reader to examine all the Cauſes of Irregularity in the magnetic Attraction. I think I have already ſaid enough to convince any one, that all theſe Varieties may ariſe, from the different Manner in which the magnetical Streams are made to move and act; and that the magnetical Attraction is really in itſelf no ways different from that of Coheſion and Gravity: And the Truth of the Propoſition is alſo clear, that the Quantities of relative Magnetiſm may be different at different Diſtances, and in different Ratio's of thoſe Diſtances: From whence, and from what has been proved above, I beg leave to draw the following Corollaries.

### COROL. I.

The Force of magnetic Attraction is never at all Diſtances in the ſame Ratio of the Diſtances.

### COROL. II.

The Force of magnetic Attraction betwixt the ſame Loadſtones, and at the ſame Diſtances, may be very different, if the two Poles that are oppoſed to each other be only turned round a little Way upon their Axis, ſo as to make different Parts of the Polar Surfaces reſpect each other differently, §. 7.

### COROL. III.

If a generous Loadſtone be applied to a weaker, there will be a Kind of Repulſion even betwixt their friendly Poles, but its Force will be overpowered by the ſtronger Force of Attraction.

### COROL. IV.

Large Loadſtones will be able to act at a greater Diſtance than ſmall ones, though the Quantities of abſolute Magnetiſm be even leſs in them than in the ſmall ones; becauſe the Axis of a large Loadſtone being longer, and the Poles at a greater Diſtance, the repellent Matter will not be drawn from one Pole to the other with ſo much Strength, but be carried more in the Direction of its projectile Force, and move round from one Pole to the other in larger Curves: Its Sphere of Action will therefore be more extenſive.

### COROL. V.

If Loadſtones are long and ſlender, their Spheres of Activity will be proportionably greater; for the ſame Reaſons.

### COROL. VI.

Thicker Armour will be required, when the Poles are at a greater Diſtance, *cæteris paribus*, and *vice verſâ*; becauſe the Uſe of the Armour is to ſtop the Flux of magnetic Virtue; and by carrying it down into the Feet, to convey it all from one Pole to the other through them. Now the nearer the Poles are, the ſooner the projectile Force of the magnetic Virtue is overcome, § 2. and conſequently thinner Armour will be required to conduce to that Effect; and *vice verſâ.*

### COROL. VII.

Since ſmall Loadſtones will have the leaſt Spheres of Activity, they will act at a leſs Diſtance; but then at ſmall Diſtances they ought to be more vigorous, becauſe their Streams of repellent Matter, moving in a leſs Compaſs, muſt be denſer.

## PROP. LXXX.

If the two South Poles or two North Poles be applied to each other, they will mutually repel each other.

It is eaſy to conceive, that when the two Poles that have both a Stream of repellent Matter coming out of them, are oppoſed to each other, they will be mutually repelled by the Conflux of the two Streams, and the Accumulation of repellent Matter thereby produced: But the Reaſon of the Repulſion of the North Poles is not quite ſo obvious,

vious, though the Cauſe be much the ſame in both Caſes; for there muſt be a Conflux of repellent Matter towards both Poles to ſupply their Streams, which muſt make a double Flux of it towards the intermediate Space; and becauſe both the North Poles are ſupplied by Streams coming from their contrary South Poles, the Stream coming to the one will be oppoſite to that coming to the other.

## PROP. LXXXI.

If the two unfriendly Poles be brought in Contact, they will in ſome Caſes continue to repel; but in others, they will begin to attract at a little Diſtance before they come in Contact.

When the repellent Forces of both are equally vigorous, they will continue to the very Point of Contact; but if one Loadſtone is much ſtronger than the other, it will be able to invert the Polarity of the weaker about the Part with which it is nearly in Contact. From hence we may underſtand an odd Fact, oddly related by ſome of the old Writers upon Loadſtones: They ſay, that if two Loadſtones, a ſtronger and a weaker, have their repellent Poles brought together, the weaker will have its Virtue put in Confuſion, and be as it were inebriated, and will not come to itſelf for ſome Days. The Caſe, in ſhort, ſeems to be this: The Polarity of the Part which was in Contact becomes inverted by the Force of the ſtronger Stone; but that Inverſion not reaching far beyond the Polar Surface, and the Virtue of the greater Part of the Stone remaining ſtill unaltered, it is able by its contrary Force to reſtore the confuſed Part to itſelf again in a few Days. But what Mr. *Boyle* relates from his own Experience deſerves much better our Attention: He ſays, that taking a very ſmall Fragment of a Loadſtone, and applying ſometimes one Pole, and ſometimes the other, to the Poles of a very vigorous one, he could change the Poles of the little Fragment, though by applying a larger Piece he was not able, in many more Hours than he employed Minutes before, to make any ſenſible Change of the Poles.

## PROP. LXXXII.

The Attraction of Magnetiſm may be peculiar to one Kind of Bodies, without ever acting upon others, or being terrupted by them.

If only one Kind of Bodies have their Parts ſo conſtituted, as to admit within their Pores more repellent Matter, than what belongs to the Space occupied by the Pores, then will the Attraction of Magnetiſm be peculiar to one kind of Bodies, *Prop.* 77, and it will not act upon other Bodies, or be interrupted by them: For the repellent Fluid can readily paſs through the Pores without Interruption, when it moves in a Stream; becauſe they much exceed the ſolid Parts, and are always open, *Prop.* 50. *Corol.* 2. The Caſe is much different, when the Motion of repellent Matter is propagated by Vibrations, from what it will be, when moving in a Stream like that of Magnetiſm; for in Proportion as the Stream of repellent Matter meets with Reſiſtance from the ſolid Parts, it will croud in ſo much the faſter at the Pores: for Example, ſuppoſe a Stream is paſſing through a Piece of Gold, and is in Part ſtop'd at the firſt Surface by the ſolid Parts, then the repellent Matter will be there accumulated and condenſed; and to reſtore the *Equilibrium*, it will croud in at the Pores with greater Velocity and in greater Quantities, in Proportion to the Degree of Condenſation. As long as the Stream continues to be impeded, ſo long will it continue to be accumulated, condenſed, and accelerated in its Paſſage; till at length it is carried through as faſt as it arrives, without any Impediment. Now if the repellent Matter in the Pores is no more than what belongs to the Space occupied by them, independent of the ſolid Parts, it is no Part of that which belongs to the Body, nor any way contributes towards ballancing its Force of Attraction: Its being put in Motion, therefore, will not make the Body in whoſe Pores it moves, magnetical. That the repellent Matter contained in the Pores of moſt Bodies is no more than what belongs to the Space occupied by them, appears from *Prop.* 74. Therefore Magnetiſm may be peculiar to one Kind of Bodies, without ever acting upon others, or being interrupted by them.

## COROL.

The Reaſon why no other Bodies but Iron, and ſuch as contain Iron, are magnetical, is plainly this: No other Bodies contain more repellent Matter in their Pores than what belongs to the Space occupied by the Pores; for it follows from *Prop.* 77, that they would be magnetical if they did.

## PROP. LXXXIII.

The Reaſon why Iron contains more repellent Matter in its Pores, than what belongs to the Space occupied by them, may be explained from the peculiar Conſtruction of the Pores of Iron.

M^r^. *De Reaumur*, in his *Treatiſe upon Steel* (a Work deſervedly admired) has explained the Structure of a little Grain of Steel, as it appears in a Microſcope: It conſiſts of a great Number of *Moleculæ*, adhering together, without any Order or Regularity: each of theſe *Moleculæ* are compounded of others, no leſs irregular and confuſed; and probably even thoſe may be a Compound of others ſtill leſs: But ſuppoſe the Gradation goes no further, and theſe laſt viſible *Moleculæ* are compounded of the primary conſtituent Corpuſcles of Steel, it is evident from this Kind of Structure, that there muſt be a Gradation of Pores as well as ſolid Parts; and that the largeſt Claſs of Pores, when compared with the ſmalleſt, are very wide Cavities, whoſe Sides are at too great a Diſtance to admit of a Repulſion of their Surfaces; for that Kind of Repulſion can act but at a very ſmall Diſtance, as appears from *Prop.*42.*Corol.*1. The repellent Matter may therefore be condenſed in thoſe, and many of the inferior Claſſes of Pores, perhaps in all except the ſmalleſt, that are formed betwixt the primary Corpuſcles; by which Means more repellent Matter will be contained in the Pores of Steel, than merely what belongs to the Space occupied by them. The larger Pores of Iron are differently conſtructed from thoſe of Steel; but there is no Reaſon to doubt, but that there are the ſame Gradations of Pores. There is no Subſtance, that I know of, ſo unlikely to have Air incorporated with it, as ſolid Iron or Steel: For they are, whilſt ſeparated from the Ore, expoſed to the intenſeſt Degree of Heat; and moſt of the Changes, undergone afterwards, are effected in a red hot State at leaſt: So that if they contain any Air, it cannot be much, and that only in their largeſt Pores. From what has been ſaid it appears, that neither of the two Cauſes mentioned, *Prop*. 74, exiſt in Iron or Steel, in any Degree ſufficient to prevent the repellent Matter from being condenſed in their Pores.

## PROP. LXXXIV.

The Attraction between Loadſtones and Iron is owing to the very ſame Cauſe, as that betwixt Loadſtone and Loadſtone.

For though Iron has no fixed Magnetiſm itſelf, yet as ſoon as it is brought within the Action of a Loadſtone, it becomes magnetical, and has all the Properties of the Loadſtone as long as it continues there.

## COROL. I.

The Difference betwixt the Magnetiſm of Loadſtones and Iron conſiſts in the magnetical Streams being permanent in the firſt, but not in the latter.

## COROL. II.

If there be found two Bodies, which only differ in the Arrangement of their Parts; one of which has a fixed Magnetiſm, and the other not, the different Arrangement of their Parts will be the Cauſe of their different Magnetiſm.

## COROL. III.

Since Steel that is hardened will receive a permanent Magnetiſm, and ſoft Steel will not; if we can find out the Difference betwixt the Arrangement of the Parts in ſoft and hardened Steel, that will lead us to the Cauſe of the Fixedneſs of Magnetiſm: For I think it cannot be reaſonably ſuppoſed that ſoft Steel differs from hard in any Thing but the Arrangement of the Parts.

## PROP. LXXXV.

The Difference of ſoft and hardened Steel conſiſts in this: The firſt contains its *Phlogiſton* chiefly in its largeſt Pores; the latter contains it in the ſmaller.

§. 1. The Facts on which I ſhall found the Demonſtration of this Propoſition, are to be met with in that excellent Treatiſe of M^r^. *De Reaumur*, already mentioned. That there is in Steel a very large Quantity of the *Phlogiſton*, is beyond Doubt: It was obſerved in *Prop.* 76, that Blackneſs, when it appeared in Metals, was owing to the *Phlogiſton*, which does not reflect Light like other Bodies. Accordingly ſoft Steel has a duſky Appearance; ſo that we ſee the *Phlogiſton* in its Pores with the naked Eye. When it is very hard, the Appearance is quite otherwiſe: It is then white; and the little Grains are not only white, but reflect ſo much Light as to be quite brilliant, and ſparkle like little Diamonds. Where now is the *Phlogiſton?* Is it fled away, or is it only retired behind the Scenes? It is certainly no longer viſible. If it remains, it muſt have penetrated deeper into the Subſtance of the Steel, and have hid itſelf in the inviſible Pores. Take the hardened Steel, and lay it upon Charcoal, or any thing that is red-hot, that it may gradually return to its former Softneſs, and you will perceive that it is not fled away: It comes out again into the viſible Pores, as the Steel grows hot; and even ſpreads itſelf all over the outward Surface. What comes out at firſt is not ſufficient to ſuffocate the Vibrations of Light ſo much, but that it is reflected in Colours: Firſt it becomes paler; then has a yellowiſh Caſt, or Straw-colour; then a ſtronger Yellow; then a Gold-colour; after that, a Gold-colour mixed with Purple; then a Purple; then deeper and deeper, till it becomes a Violet: This changes at length to a deep Blue; which at laſt degenerates to a duſky Water-colour. Thus we ſee the *Phlogiſton* come out of the inviſible Pores again, into the larger; which therefore reflect the Vibrations of Light weaker and weaker, till at laſt the large Pores being again filled with it, appear black, as before. And what plainly ſhews that the *Phlogiſton* comes out from betwixt the very component Corpuſcles, is this: It not only makes its Appearance in the large Pores, but all over the outward Surface of the Steel, which is the ſame with the outward Surface of the external Corpuſcles that compoſe it. If the Steel be quenched when it comes to a deep Blue, the *Phlogiſton* remains fixed upon the Surface, which continues blue: If you rub it off, or continue the Heat till it flies away, the Surface then has the common Colour of Steel; that is, a duſky Brightneſs: The ſolid Parts reflect Light, whilſt the Pores are black. Let us now inquire the Reaſons why the *Phlogiſton* retires into the ſmalleſt Pores of Steel heated to a violent Degree, and why it is fixed there by quenching it in Water. It appears from our general Account of the component Corpuſcles of Bodies, that thoſe of Steel muſt be ſome of the largeſt in Nature: The Weight, Denſity, and Hardneſs of Steel are all Proofs of that Truth. The component Corpuſcles muſt therefore have ſingly among themſelves a very great Force of Attraction; and if we ſuppoſe a Number of them collected together in a Body, ſo as to form one of the ſmalleſt Grains of Steel, ſuch a Grain will be vaſtly denſe: The Force of Attraction betwixt each Corpuſcle will bring them very near each other; and conſequently the Pores will be very ſmall, conſidering the Size of the Corpuſcles: Each Grain will alſo have a great Force of Attraction. A Number of theſe Grains brought in Contact make larger; thoſe, larger ſtill; and ſo on. Suppoſe the Pores filled with the *Phlogiſton*, and we have an Idea of ſoft Steel; the Particles of *Phlogiſton* are but one Size bigger than thoſe of Water, and their ſmall Attraction amongſt themſelves will remove them but one Degree from Fluidity: Therefore when the Pores of Steel are filled with them, the Attraction between the little Grains will be leſſened, by the Introduction of a Subſtance amongſt them that has very little Coheſion in itſelf. The little Corpuſcles of the *Phlogiſton* will be ſtrongly attracted by the minuteſt Grains, cover over their Surfaces, inſinuate themſelves betwixt them, and ſerve as Rollers to enable them to ſlide with leſs Friction one upon another. Hence the Cauſe of Ductility and Flexibility, hence the Blackneſs of Steel, as well as all other Metals, when their Parts are ſeparated, and they reduced to an impalpable Powder, by continual Attrition: But the *Phlogiſton* cannot enter into the ſmall Pores betwixt the component Corpuſcles of the ſmalleſt Grains: The Minuteneſs of thoſe Pores will not readily admit them; and the ſtrong Coheſion of the Corpuſcles

puſcles themſelves will not allow the Pores to dilate for their Reception. When the Steel is made intenſely hot, all its Parts are dilated; the very component Corpuſcles are removed to a great Diſtance from each other, in Compariſon to what they were before. The *Phlogiſton* may now enter; and though it be violently dilated itſelf, yet the Attraction being ſo much ſtronger in the Pores betwixt the component Corpuſcles, than it is in the larger Vacuities betwixt the Grains, it will be all drawn in betwixt the component Corpuſcles. If now you quench the Steel in cold Water, the ſudden Removal of the Heat makes all the Parts run into Contact, before the *Phlogiſton* has Time to eſcape out of the Pores betwixt the component Corpuſcles: They are therefore ſhut up there, and the Vacuities betwixt the Grains are left empty. The ſmalleſt Grains are no longer diſunited by the *Phlogiſton*; they adhere together with all their Force of Attraction: The larger Grains that are compounded of them adhere to each other in like Manner; but as they touch but in few Points, their Force of Coheſion is leſs than before: The *Phlogiſton*, which before filled up the Vacuities betwixt them, and increaſed the Points of Contact, being now removed, the ſudden Cold, and the Want of the *Phlogiſton* to interpoſe itſelf betwixt the ſmaller Grains, makes them run together into larger *Moleculæ*, whence the largeſt Grains exceed thoſe of ſoft Steel. This likewiſe diminiſhes the Number of Points of Contact. The Want of the *Phlogiſton* betwixt the Grains takes away the former Ductility. The Parts are hard and brittle; and will ſooner ſeparate than ſlide upon each other. The outward Surface has the Air ſtrongly condenſed upon it, on Account of its powerful Attraction. All the Light that falls upon it is reflected from the large Grains: Hence their ſparkling Appearance. If the Steel be quenched with a leſs Degree of Heat, the Grains are leſs, becauſe fewer ſmall ones have run together to make one large one: They have alſo duſky Parts interſperſed amongſt them, which is owing to the *Phlogiſton*; ſome of which yet remains in the large Pores, the Heat not being ſufficient to dilate the Pores betwixt the component Corpuſcles, enough for them to receive it all. When Steel is quite hard, it takes up more Space than when ſoft, becauſe its leaſt component Grains are ſwelled by the Admiſſion of the *Phlogiſton* into their Pores.

§. 2. Now let us conſider how Magnetiſm will be affected by this different Arrangement of the Pores. In ſoft Steel the Pores of the leaſt Grains can have nothing to do with Magnetiſm, becauſe of their Smallneſs, and the ſtrong Repulſion of the Surfaces of their component Corpuſcles: Theſe will not contain more repellent Matter than what belongs to the Space occupied by them: We muſt therefore look for it in the Pores betwixt the Grains. Theſe are filled with the *Phlogiſton*, which is not only looſe in thoſe Cavities, but adheres ſtrongly to the Surfaces of the Grains that compoſe them: The Condenſation therefore of repellent Matter will be removed from thoſe Surfaces, by the Repulſion betwixt them, and the Surfaces of the Corpuſcles of *Phlogiſton*, which adhere to, and are condenſed upon them. It will therefore be chiefly found in the Centers of theſe Vacuities; where it will be free, and ready to be put in Motion in any Direction. This repellent Matter may be plentifully condenſed in the Centers of theſe Cavities, and yet have little Attachment to any of the ſolid Parts; only the Corpuſcles of the *Phlogiſton* may detain it a little by their weak Attraction. Suppoſe this repellent Matter is made to move in a Stream, by the Preſence of a Loadſtone; it is put in Motion with the greateſt Facility; it paſſes without any Impediment from Pore to Pore; only the ſmalleſt Grains do not tranſmit it ſo freely through them: Now remove the Loadſtone that firſt produced the Stream in this Piece of Steel, and ſee if the Stream will continue: In Fact it does not. But why? The repellent Matter that moves out at the South Pole is not ſupplied by freſh at the oppoſite Side. It can be ſupplied near at hand: Nothing hinders it from flowing from all Quarters, ſince it is every where free.

§. 3. In hardened Steel the Caſe is very different; there the large Pores are quite empty of *Phlogiſton*, contain nothing but repellent Matter, and that ſtrongly condenſed upon the internal Surfaces of the Pores, and tied down there as it were by Attraction, not eaſily to be put in Motion. For this Reaſon it is difficult to make a Stream of repellent Matter in hardened Steel; but when once it is produced, it is as difficult to ſtop it. A Stream in one Part cannot be ſupplied from any of the neighbouring Parts indifferently: It muſt be ſupplied from thoſe behind; where the repellent Matter is in Motion in its own Direction. That in the adjacent Pores is either moving itſelf in a parallel Stream, or at Reſt, and not eaſily to be put in Motion: It is for this Reaſon that a Loadſtone will but very little attract Steel, when well hardened; its Virtue not eaſily penetrating the Pores of it ſtrongly enough to commence a magnetical Stream.

## COROL. I.

Therefore the Difference between fixed and unfixed Magnetiſm depends on the greater or leſs Force, required to put the repellent Matter in Motion; according as it is more or leſs fixed in the Pores.

## COROL. II.

Since in Loadſtones their Magnetiſm is no leſs fixed and unchangeable than in hardened Steel; and we have no Reaſon to conclude, that the Structure of the Pores in Loadſtones is not as capable of fixing the repellent Matter, we ought to ſuppoſe it analogous to that of hardened Steel; that we may not multiply Cauſes without Neceſſity. It may be ſufficient to obſerve, in reſpect to the Texture of Loadſtones, that generally they are very hard, and brittle; and, *cæteris paribus*, more vigorous in Proportion to their Degree of Hardneſs: That Emery, and ſome other Iron Ores made uſe of for poliſhing, on Account of their containing very hard Particles, have a great Number that are vigorouſly attracted by the Loadſtone.

## PROP. LXXXVI.

All Cauſes, that are capable of making the repellent Fluid move in a Stream, are capable of producing Magnetiſm in Bodies duly qualified to receive it.

This is evident from our Explication of Magnetiſm in general; and is further confirmed by a Variety of Facts. When Iron or Steel undergo a violent Attrition in any one particular Part, the Air, that is ſtrongly united and condenſed upon the Part, being removed by the Attrition, the repellent Matter ruſhes in to ſupply its Place: It ſtops not at the Surface, but in Part enters the Pores with the *Impetus* that it has acquired. In its Conflux it dilates the Part, and produces Heat; and at the ſame Time a Stream of Magnetiſm. The Part where it enters becomes a North Pole. If it be hardened Steel, as in the Caſe of Drills, it acquires a fixed Magnetiſm: If it be ſoft Iron, the Magnetiſm remains no longer than whilſt the Heat continues; becauſe Iron takes no fixed Magnetiſm: The Stream ceaſes with the Heat, as Mr. *Boyle* has obſerved. Lightning is the ſtrongeſt Power, yet known, in producing a Stream of Magnetiſm: It is able in an Inſtant to render hardened Steel ſtrongly magnetical; or to invert the Polarity of a Mariner's Compaſs: Like Magnetiſm, it frequently paſſes through other Bodies, without Reſiſtance; and yet acts ſo violently upon Steel, as to melt it. So that probably if we could produce by Art the ſame violent Stream, we might inſtantly render Steel magnetical to a ſurpriſing Degree, ſtrengthen Loadſtones, and invert their Poles inſtantaneouſly, or place them how we pleaſe, and that even when they are ſurrounded by other Subſtances. The late ſurpriſing Diſcoveries in Electricity have furniſhed us with ſomething very like Lightning. The great Profeſſor *Muſſchenbroek*, and many others ſince him, have felt the Violence of its Effects: What may be done by it in regard to Magnetiſm muſt be the Work of future Diſcoveries.

The common Methods of producing Magnetiſm are founded upon the ſame Principles as that of touching a

Needle, and depend upon nothing more than placing the Body that is not magnetical in the Stream of one that is ſo already; and contriving Matters ſo, that the magnetical Stream ſhall enter the Body with as much Force as poſſible, and be carried through it in one Direction, ſo as to go in at one Part, and come out at the Part directly oppoſite. This Method does very well for touching Needles, and other ſlender Pieces of Steel; but does not anſwer ſo well when the Piece is thick, becauſe the Stream is chiefly applied to the outward Surface, and has not Force enough to penetrate to any conſiderable Depth of the Steel, eſpecially if it be very hard, as it ought to be to make the Magnetiſm fixed. Rubbing with Iron Bars placed in the magnetical Line, produces the ſame Effect, in the ſame Manner. Large Loadſtones frequently give a very good Touch, though their Virtue be leſs denſe than that of ſmaller; becauſe their Virtue moves more in right Lines, acts at a greater Diſtance, and is eaſier made to converge towards the Point of Contact. Sometimes ſmall Loadſtones are ſo vigorous as to give a very ſtrong Touch to a ſlender Needle, by communicating a very denſe Stream.

### COROL.

Since when a Body is red hot the repellent Fluid is made to move in all Directions, the Stream of Magnetiſm muſt be confuſed thereby, and its Direction be deſtroyed: Hence the Reaſon why Fire deſtroys Magnetiſm.

### PROP. LXXXVII.

The Earth may be conſidered as a great Loadſtone, whoſe magnetical Parts are diſpoſed in a very irregular Manner.

All the *Phænomena* attending the Direction of the Needle in different Parts of the Earth, in a great Meaſure correſpond with what happens to a Needle when placed upon a large *Terrella*; if we make an Allowance for the different Diſpoſition of the magnetical Parts in reſpect to each other, and conſider the South Pole of the Earth to be a North Pole in reſpect to Magnetiſm. When the Needle is placed upon the *Terrella* at an equal Diſtance betwixt the South and North Pole, the South Pole of the Needle points towards the North of the *Terrella*, the Needle is equally attracted by both (if both Poles are equally ſtrong) and diſpoſes itſelf in a Line parallel to the Axis: Move it towards the South Pole, and the North End of the Needle dips downwards, and that more and more, the farther it is moved towards the South: On the other Side of the Equator, the South End will dip in like Manner. This is the Caſe, if the *Terrella* has its Virtue coming out of its Poles in an uniform Manner; but if it comes out in Spots here and there, at different Diſtances from the Axis, the Needle will in many Places vary from the Direction of the Axis, both horizontally and vertically, even when placed upon the Equator, but more ſo at ſome Diſtance from it: For Example, ſuppoſe a large Quantity of magnetic Virtue comes out at the Diſtance of 20 Degrees from the South Pole (this I call a falſe Pole) and let the Needle be placed upon the Equator at ſuch a Part, that a Line drawn from thence through the falſe Pole, may paſs alſo through the true one; the Needle in this Place cannot point towards the falſe Pole, but it muſt likewiſe point towards the true one: There will be no Variation here, nor in any Part of the intermediate Space laying directly betwixt this Point of the Equator and the falſe Pole: Therefore a Line drawn from hence to the falſe Pole will be a Line of no Variation; only the dipping Force will increaſe much faſter in moving the Needle along this Line from the Equator towards the falſe Pole, than it would do in caſe there was none, and it was moved in the ſame Line towards the true Pole. Now if the Needle be moved upon the Equator from the former Point on either Side, it muſt then vary more and more, the farther it is removed from it: for then a Line drawn from the Needle to the falſe Pole will not paſs through the true one; and both Poles being ſuppoſed to act upon it at the ſame Time, it muſt point in the Direction of the Diagonal of the two Forces; which Direction will vary more and more from that of the true Pole, in Proportion as the Needle is moved farther from the Line of no Variation, and alſo in Proportion as it is brought nearer the falſe Pole, in moving it from the Equator. If there be ſeveral falſe Poles, there will be more Cauſes of Variation; and the Forces will be more compounded, and the Theory of the Variation be thereby rendered more complex. Now conſidering the Earth as a great Loadſtone, very heterogeneous in its Parts, there may be a great Number of theſe falſe Poles both to the South and North of the Equator, to which the Irregularity of the Variation may be reaſonably aſcribed. Here is no Occaſion for the leaſt Hypotheſis: The Needle is acted upon by the Earth in the ſame Manner as by a Loadſtone that is heterogeneous in its Parts; and if the Earth produces the ſame Effects as a Loadſtone, is it not a Loadſtone? That the Earth has its magnetical Parts diſpoſed in an irregular Manner, is no leſs evident: Wherever there is Magnetiſm there is Iron, and where there is no Iron there is no Magnetiſm. But is Iron equally diſpoſed over all Parts of the Earth? No certainly: Some Countries abound with it much more than others. Why then may not ſome Countries have more Magnetiſm than others? But it may be anſwered, that all Iron Ores are not magnetical, and that therefore a Country may abound with them, without having any Magnetiſm. I grant it; but though moſt Iron Ores are without Magnetiſm, yet they are all capable of having it, and thoſe that have it are capable of loſing it. The curious Experiments of Dr. *Muſſchenbroek* will make it appear, that when Iron has an Acid united with it, it is incapable of becoming magnetical: When you ſeparate the Acid and reſtore the *Phlogiſton*, it becomes as readily magnetical as ever. An Iron Ore that has the vitriolic Acid united to it, can never become magnetical, unleſs the Acid be firſt ſeparated: But have we any Reaſon to imagine, that Ores remain always in the ſame State in the Mines? The Miners tell us quite the contrary: They ſay that they find by long Experience, that Ores are continually approaching nearer and nearer to a State of Perfection, and then

degenerate

degenerate again. What is then the moſt perfect State of a Metal? Is it not that State in which it puts on a true metalline Form; *e. g.* Is not Virgin Copper in its moſt perfect State? Wherein does it differ from its more imperfect Ores, but by being freed from the univerſal Acid, and being united to the *Phlogiſton*? If it was again corroded by the ſame Acid, it would more and more degenerate from its State of Perfection. Iron is never found in a Virgin State more than in a Loadſtone: It is then free from the vitriolic Acid, and united to the *Phlogiſton*; and ſome Loadſtones have even a metallic Appearance. We grant therefore, that the common Iron Ores are unmagnetical; but allowing them capable of coming to a greater Perfection in a long Courſe of Years, it will follow, that Iron Mines are pregnant with Loadſtones not yet come to Maturity, and may in Time become Mines of good Loadſtones: In a like Courſe of Years the vague Acid may return again, corrode them, and deſtroy their Magnetiſm. Thus the falſe Poles may decreaſe in Force every Year, and even new ones be generated where there were none before. From hence we ſee not only the Cauſe of the Variation, but why it does not always remain the ſame in the ſame Place.

It follows from hence, that the Variation will not alter according to any regular Law: And, that the only Way to come at a Certainty in Regard to it, is to regiſter the Obſervations of Mariners from Year to Year; to form new Tables from ſuch Journals as are found beſt to agree together, and publiſh them as oft as poſſible, or as oft as ſhall be found neceſſary. Meſſ. *Mountaine* and *Dodſon* were lately engaged in this laudable Attempt at *London*; and from the beſt Collection of Facts, they were able to come at, have corrected the Chart formerly publiſhed by Dr. *Halley*; and with it have given a ſhort Account of what they have done, and ſhewn the Neceſſity there is of forming new Tables or Charts, from Time to Time, as often as we can be ſupplied with Obſervations. It appears by the Alterations ſince the Time of Dr. *Halley*, that the Variation does not alter according to any regular

Law, as thoſe Gentlemen have obſerved: ſo that we muſt not look for regular Cauſes where the Effects are irregular.

## PROP. LXXXVIII.

There muſt be ſome Cauſe that firſt gave Magnetiſm to the Earth, and continues to renew it.

If the Parts of our Globe had been never ſo well diſpoſed to receive Magnetiſm at the firſt Creation, it might have yet remained unmagnetical, unleſs there was ſome Cauſe exiſting, capable of making the repellent Matter move in a Stream through it: and if the magnetical Parts are continually becoming unfit for receiving the magnetical Stream, whilſt others become ſuſceptible of it, there ſeems a Neceſſity that the ſame Cauſe ſhould continue to act; that the new magnetical Parts may be actually impregnated with Magnetiſm.

## PROP. LXXXIX.

This Cauſe muſt be a very extenſive one.

Otherwiſe it could not produce ſo extenſive an Effect, as to make the whole Earth magnetical.

## PROP. XC.

This Cauſe muſt act in ſuch a Manner, as to make the magnetical Stream enter at the South Pole of the Earth.

Becauſe the South Pole of the Earth is the North Pole in reſpect to Magnetiſm.

## PROP. XCI.

If the Earth revolves round the Sun in an Ellipſis, and the South Pole of the Earth is directed towards the Sun at the Time of its Deſcent towards it, a Stream of repellent Matter will thereby be made to enter at the South Pole, and come out at the North.

All the Time that the Earth is deſcending towards the Sun, it meets with a greater Denſity in the repellent Fluid that compoſes the Sun's repellent Atmoſphere; therefore the South Pole, moving firſt, will have the repellent Fluid continually entering into its Pores, otherwiſe the Denſity within the Pores would be continually leſs and leſs, in Proportion to the Denſity without; and to make the Denſity proportionable throughout the Pores of the whole Globe, it muſt paſs ſucceſſively from Pore to Pore quite through the Globe. By this Means a Stream will be commenced, that enters at the South Pole, and comes out at the North: This Stream, once begun, will continue whilſt the Earth is returning from the Sun; for before the Equinox the South Pole is ſtill in a denſer Part of the repellent Fluid than the North, being nearer the Sun; and therefore the Stream will not be carried back again through the Pores of the Earth from North to South, but as ſoon as it eſcapes out at the North Pole, coming into a rarer Medium, will diſperſe every Way; and as the South Pole moves now into a rarer Medium continually, the Stream of Magnetiſm will be ſupplied by repellent Matter brought round from the North Pole. After the Equinox the North Pole being turned towards the Sun, the Stream will be made ſtronger by the Earth's receding into a Part where the repellent Fluid is rarer; for then the repellent Matter will be denſer in the Pores about the North Pole than in the Space ſurrounding it, and will come out the faſter: But the Stream will be moſt accelerated in Winter, when the Earth is deſcending near its *Perihelion*; becauſe its Motion is then quickeſt. This may be one Reaſon why Magnetiſm is ſtronger in Winter than in Summer. It is probable, on this Principle, that the Earth's magnetical North Poles lie at a conſiderable Diſtance on this Side the antarctick Circle; for the Stream ought to enter in the Parts about the Southern Tropick; which is a Circumſtance, that I think is confirmed by ſuch Obſervations as have been made in regard to the Magnetiſm on the South Side of the Line; and it ſhews us a new Reaſon for the Variation, very conſiſtent with the preceding Explication of it. Thus, I think, we have found out a Cauſe that will account for the Production of Magnetiſm in the Earth, and continue, or perhaps improve it perpetually, from Year to Year: Probably it has been improving ever ſince the Creation; which may be one Reaſon why the Uſe of the Compaſs was not diſcovered ſooner.

## The CONCLUSION.

I have now gone through moſt of the grand *Phænomena* of Nature, except Electricity; but that is too great a Taſk at preſent: I therefore muſt beg Leave to defer it; and ſhall only add this Obſervation, that it will not be difficult to foreſee, that theſe ſimple Principles will be able to do much in explaining ſuch *Phænomena* as are generally attended with various Attractions and Repulſions, and Sparks of Fire. When we rub the Surfaces of Bodies, and put the repellent Matter on them in Motion, what are we to expect but new Streams of repellent Matter, different from thoſe of Magnetiſm, but capable of producing as extraordinary Appearances?

*FINIS.*